SUBSURFACE INJECTION EVALUATION
TECHNICAL REPORT

SKAGIT VALLEY CASINO RESORT

Skagit County, Washington

Prepared for:
Wilson Engineering, LLC
805 Dupont Street, Suite 7
Bellingham, WA 98225

Prepared by:
Associated Earth Sciences, Inc.
2911 ½ Hewitt Avenue, Suite 2
Everett, WA 98201
425-259-0522
Fax: 425-252-3408

October 3 2008
Project No. EH080149A

Wilson
SURVEY/ENGINEERING

October 6, 2008

VIA REGULAR MAIL

Ms. Jennifer Parker
Ground Water Unit
U. S. Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 900, OCE-082
Seattle, Washington 98101
Phone: 206–553-1900

Re: Upper Skagit Indian Tribe, Proposed Water Reclamation Facility
EPA Form 7520-16 for proposed Inventory of Injection Wells

Dear Ms. Parker:

As we discussed over the phone earlier this year, the Upper Skagit Indian Tribe is planning to construct a new wastewater treatment facility to serve Tribal connections on the Bow Hill Road Reservation. Currently, the Tribe's wastewater is pumped to the Burlington force main (routed along Old Highway 99) which is maintained by Samish Water District. The existing sewer connection is not adequate for future sewer demands and, in light of this; the Tribe has evaluated other wastewater treatment options.

The preferred option is to design and build an on-site wastewater treatment facility which will serve existing and future Tribal connections, allowing development of the Skagit Resort area. In addition, the facility will use a membrane bioreactor treatment process and effluent will be treated to Class A Reclaimed Water Standards. The proposed location for the wastewater treatment facility and discharge is on tribal trust land, see attached Sheets 1 and 2. The primary reasons for switching from the Burlington force main to a new on-site treatment facility are as follows:

- Wastewater will be treated to a higher standard then currently treated at the Burlington WWTP.
- The Tribe will have the ability to reuse the reclaimed water (treated effluent) for beneficial purposes, such as flushing toilets, irrigation, etc.
- Raw wastewater is less likely to leak out of an on-site treatment system, minimizing pollution concerns. The Burlington WWTP is over 7 miles away.
- The Tribe will not need to invest the capital needed to improve the existing Burlington force main connection. It was estimated that 3000 feet of 8" sewer pipe would need to be replaced along a remote 20' wide easement with challenging work conditions (slopes greater then 20%).

- The Tribe will no longer be responsible for operation and maintenance costs associated with the existing Burlington force main connection.

The Tribe has evaluated discharge options, and after several months of hydrogeological investigations, it has been concluded that the most feasible design includes injection of highly treated effluent into a permeable geologic unit below the surface. The Subsurface Injection Evaluation Technical Report is provided for your information.

The proposed design discharge parameters for wastewater constituents of concern are compliant with EPA Primary Drinking Water Standards. The proposed treated effluent will meet the following standards:

- BOD_5 ≤5 mg/L
- TSS ≤5 mg/L
- Average Turbidity ≤0.2 NTU, 0.5 NTU Max (Class A Reclaimed Water Standard)
- Total Coliform = Non-detect (Class A Reclaimed Water Standard)
- Total Nitrogen ≤10 mg/L

Also attached is the proposed Inventory of Injection Wells (EPA Form 7520-16). Two Class V (Type 5D) injection wells are proposed, each one sized to handle the 20-YR build-out flow projection (200,000 gpd – Average Daily Flow).

Please review at your earliest convenience.
Do not hesitate to call if any additional information is needed.

Sincerely,
Wilson Engineering, LLC

Jeffrey G. Christner, P.E.

attachments:

- Inventory of Injection Wells
- Sheet 1 of 2 – Water Reclamation Facility - Well Location Map
- Sheet 2 of 2 – Water Reclamation Facility - Proposed Layout
- Subsurface Injection Evaluation Technical Report

cc: Bob Hayden, Corporate Project Manager, Upper Skagit Indian Tribe, 5984 N. Darrk Lane, Bow, WA 98232

Type or print all information. See reverse for instructions.

OMB No. 2040-0042 Approval Expires 4/30/07

INVENTORY OF INJECTION WELLS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF GROUND WATER AND DRINKING WATER

(This information is collected under the authority of the Safe Drinking Water Act)

1. DATE PREPARED *(Year, Month, Day)*: 08-10-06

2. FACILITY ID NUMBER: Unknown

PAPERWORK REDUCTION ACT NOTICE

The public reporting burden for this collection of information is estimated at about 0.5 hour per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Chief, Information Policy Branch, 2136, U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, and to the Office of Management and Budget, Paperwork Reduction Project, Washington, DC 20503.

3. TRANSACTION TYPE *(Please mark one of the following)*

- [ ] Deletion
- [x] First Time Entry
- [ ] Entry Change
- [ ] Replacement

4. FACILITY NAME AND LOCATION

A. NAME *(last, first, and middle initial)*: USIT WATER RECLAMATION FACILITY

B. STREET ADDRESS/ROUTE NUMBER: The Skagit Resort, 5984 N. Darrk Lane

C. LATITUDE

DEG	MIN	SEC
48	33	59.00

D. LONGITUDE

DEG	MIN	SEC
122	20	41.60

E. TOWNSHIP/RANGE

TOWNSHIP	RANGE	SECT	1/4 SECT
36 N	4 E	31	NW

F. CITY/TOWN: Bow

G. STATE: WA

H. ZIP CODE: 98232

I. NUMERIC COUNTY CODE: 057

J. INDIAN LAND *(mark "x")*: [x] Yes [ ] No

5. LEGAL CONTACT:

A. TYPE *(mark "x")*: [x] Owner [ ] Operator

B. NAME *(last, first, and middle initial)*: Hayden, Bob

C. PHONE *(area code and number)*: (360) 724-0168

D. ORGANIZATION: Upper Skagit Indian Tribe

E. STREET/P.O. BOX: 5984 N. Darrk Lane

F. CITY/TOWN: Bow

G. STATE: WA

H. ZIP CODE: 98232

I. OWNERSHIP *(mark "x")*

- [x] PRIVATE
- [ ] PUBLIC
- [ ] SPECIFY OTHER
- [ ] STATE
- [ ] FEDERAL

6. WELL INFORMATION:

A. CLASS AND TYPE		B. NUMBER OF WELLS		C. TOTAL NUMBER OF WELLS	D. WELL OPERATION STATUS				
		COMM	NON-COMM		UC	AC	TA	PA	AN
5	D		2	2	2				
				0					
				0					
				0					
				0					
				0					
				0					

COMMENTS *(Optional)*:

Both wells (#1 and #2) are to be used for injecting treated effluent from the proposed Upper Skagit Indian Tribe Water Reclamation Facility. Hydrogeologic Report (Subsurface Injection Evaluation, prepared by Associated Earth Sciences, Inc.) is attached. Please call if you have any questions.

KEY:

DEG = Degree
MIN = Minute
SEC = Second

SECT = Section
1/4 SECT = Quarter Section

COMM = Commercial
NON-COMM = Non-Commercial

AC = Active
UC = Under Construction
TA = Temporarily Abandoned
PA = Permanently Abandoned and Approved by State
AN = Permanently Abandoned and not Approved by State

SECTION 1. DATE PREPARED: Enter date in order of year, month, and day.

SECTION 2. FACILITY ID NUMBER: In the first two spaces, insert the appropriate U.S. Postal Service State Code. In the third space, insert one of the following one letter alphabetic identifiers:

D - DUNS Number,
G - GSA Number, or
S - State Facility Number.

In the remaining spaces, insert the appropriate nine digit DUNS, GSA, or State Facility Number. For example, A Federal facility (GSA - 123456789) located in Virginia would be entered as : VAG123456789.

SECTION 3. TRANSACTION TYPE: Place an "x" in the applicable box. See below for further instructions.

Deletion. Fill in the Facility ID Number.
First Time Entry. Fill in all the appropriate information.
Entry Change. Fill in the Facility ID Number and the information that has changed.
Replacement.

SECTION 4. FACILITY NAME AND LOCATION:

- **A. Name.** Fill in the facility's official or legal name.
- **B. Street Address.** Self Explanatory.
- **C. Latitude.** Enter the facility's latitude (all latitudes assume North Except for American Samoa).
- **D. Longitude.** Enter the facility's longitude (all longitudes assume West except Guam).
- **E. Township/Range.** Fill in the complete township and range. The first 3 spaces are numerical and the fourth is a letter (N,S,E,W) specifying a compass direction. A township is North or South of the baseline, and a range is East or West of the principal meridian (e.g., 132N, 343W).
- **F. City/Town.** Self Explanatory.
- **G. State.** Insert the U.S. Postal Service State abbreviation.
- **H. Zip Code.** Insert the five digit zip code plus any extension.

SECTION 4. FACILITY NAME & LOCATION (CONT'D.):

- **I. Numeric County Code.** Insert the numeric county code from the Federal Information Processing Standards Publication (FIPS Pub 6-1) June 15, 1970, U.S. Department of Commerce, National Bureau of Standards. For Alaska, use the Census Division Code developed by the U.S. Census Bureau.
- **J. Indian Land.** Mark an "x" in the appropriate box (Yes or No) to indicate if the facility is located on Indian land.

SECTION 5. LEGAL CONTACT:

- **A. Type.** Mark an "x" in the appropriate box to indicate the type of legal contact (Owner or Operator). For wells operated by lease, the operator is the legal contact.
- **B. Name.** Self Explanatory.
- **C. Phone.** Self Explanatory.
- **D. Organization.** If the legal contact is an individual, give the name of the business organization to expedite mail distribution.
- **E. Street/P.O. Box.** Self Explanatory.
- **F. City/Town.** Self Explanatory.
- **G. State.** Insert the U.S. Postal Service State abbreviation.
- **H. Zip Code.** Insert the five digit zip code plus any extension.
- **I. Ownership.** Place an "x" in the appropriate box to indicate ownership status.

SECTION 6. WELL INFORMATION:

- **A. Class and Type.** Fill in the Class and Type of injection wells located at the listed facility. Use the most pertinent code (specified below) to accurately describe each type of injection well. For example, 2R for a Class II Enhanced Recovery Well, or 3M for a Class III Solution Mining Well, etc.
- **B. Number of Commercial and Non-Commercial Wells.** Enter the total number of commercial and non-commercial wells for each Class/Type, as applicable.
- **C. Total Number of Wells.** Enter the total number of injection wells for each specified Class/Type.
- **D. Well Operation Status.** Enter the number of wells for each Class/Type under each operation status (see key on other side).

CLASS I Industrial, Municipal, and Radioactive Waste Disposal Wells used to inject waste below the lowermost Underground Source of Drinking Water (USDW).

TYPE	**1I**	Non-Hazardous Industrial Disposal Well.
	1M	Non-Hazardous Municipal Disposal Well.
	1H	Hazardous Waste Disposal Well injecting below the lowermost USDW.
	1R	Radioactive Waste Disposal Well.
	1X	Other Class I Wells.

CLASS II Oil and Gas Production and Storage Related Injection Wells.

TYPE	**2A**	Annular Disposal Well.
	2D	Produced Fluid Disposal Well.
	2H	Hydrocarbon Storage Well.
	2R	Enhanced Recovery Well.
	2X	Other Class II Wells.

CLASS III Special Process Injection Wells.

TYPE	**3G**	*In Situ* Gassification Well
	3M	Solution Mining Well.

CLASS III (CONT'D.)

TYPE	**3S**	Sulfur Mining Well by Frasch Process.
	3T	Geothermal Well.
	3U	Uranium Mining Well.
	3X	Other Class III Wells.

CLASS IV Wells that inject hazardous waste into/above USDWs.

TYPE	**4H**	Hazardous Facility Injection Well.
	4R	Remediation Well at RCRA or CERCLA site.

CLASS V Any Underground Injection Well not included in Classes I through IV.

TYPE	**5A**	Industrial Well.
	5B	Beneficial Use Well.
	5C	Fluid Return Well.
	5D	Sewage Treatment Effluent Well.
	5E	Cesspools (non-domestic).
	5F	Septic Systems.
	5G	Experimental Technology Well.
	5H	Drainage Well.
	5I	Mine Backfill Well.
	5J	Waste Discharge Well.

SUBSURFACE INJECTION EVALUATION
TECHNICAL REPORT

SKAGIT VALLEY CASINO RESORT

Skagit County, Washington

Prepared for:
Wilson Engineering, LLC
805 Dupont Street, Suite 7
Bellingham, Washington 98225

Prepared by:
Associated Earth Sciences, Inc.
2911 ½ Hewitt Avenue, Suite 2
Everett, Washington 98201
425-259-0522
Fax: 425-252-3408

October 3, 2008
Project No. EH080149A

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Purpose and Scope

Associated Earth Sciences, Inc. (AESI) performed a geologic/hydrogeologic assessment of an approximate 170-acre site (herein referred to here as the project site) owned by the Upper Skagit Indian Tribe (Tribe). The project site is located just east of Interstate 5 (I-5), and northeast of the intersection between Bow Hill Road and Darrk Lane in Skagit County, Washington. The approximate location of the project site, relative to surrounding physical features and domestic wells, is shown on the "Site Vicinity and Well Location Map," Figure 1. The approximate layout of the site, including the locations of exploration borings completed for this project, is shown on the "Site and Exploration Plan," Figure 2.

We understand that Wilson Engineering is assisting the Tribe in evaluating the potential to dispose of up to 200,000 gallons per day (gpd) of treated domestic wastewater in the northwest portion of the project site. The wastewater will be treated using a membrane bioreactor (MBR) wastewater treatment system prior to disposal. MBR systems have the ability to treat wastewater to a level that meets primary and secondary drinking water standards.

AESI previously completed a study of the project site to evaluate the potential for surface infiltration of the MBR-treated wastewater. A total of 22 exploration pits were completed throughout the northern portion of the project site, and one infiltration test was conducted in the Friday Creek valley near the eastern project site property line. The geology of the project site was preliminarily defined as near surface, low permeability glaciomarine drift and glacial till overlying relatively permeable glacial outwash sand and gravel. The results of our previous site evaluation indicated that the infiltration of treated wastewater in the upland portion of the project site would be limited by shallow perched ground water and the proximity of numerous wetland areas. The infiltration testing indicated that the infiltration rate in the upper portion of the Friday Creek alluvial deposits is relatively low (maximum rate of 0.22 inches per hour [in/hr]), but it may be possible to infiltrate as much as approximately 80,000 gallons per day (gpd) into the approximately 90,000 square feet (ft^2) of the project site located within the Friday Creek valley.

Although our previous site investigations indicated only limited potential to infiltrate the treated wastewater into surface soils at the project site, it did suggest that the upper portion of the underlying glacial outwash geologic unit may be suitable for injection of the treated wastewater. The details of our previous site evaluation are presented in our report to Wilson Engineering, LLC., dated February 20, 2008.

The primary purpose of our services for this phase of the project was to evaluate the potential to infiltrate/inject the MBR-treated wastewater into the upper portion of the glacial outwash sediments that underlie the project site at depth via Class V Underground Injection Control (UIC) wells. Our detailed scope of services completed for this project is presented in our approved contract with Wilson Engineering, dated February 28, 2008.

1.2 Data Review and Previous Studies

AESI reviewed available soil and geologic/hydrogeologic data to gain an understanding of existing conditions in the project area. A general summary of the most pertinent information reviewed is provided below. A detailed listing of all information reviewed for this project is included in Section 7.0, "Bibliography."

- Reports and maps published by the United States Geological Survey (USGS); the Washington State Department of Natural Resources (WDNR), Division of Geology and Earth Resources; the United States Department of Agriculture-Soil Conservation Service (USDA SCS) including:
  - *Geologic Map and Interpreted Geologic History of the Bow and Alger 7.5-Minute Quadrangles, Western Skagit County, Washington. Washington State Division of Geology and Earth Resources Open File Report 98-5, October 398 (Dragovich, et al., 1998).*
  - *Geologic Map of the Sedro-Woolley North and Lyman 7.5-Minute Quadrangles, Western Skagit County, Washington. Washington State Division of Geology and Earth Resources Open File Report 99-3, December 1999 (Dragovich, et al., 1999).*
  - *Interpreted Geologic History of the Sedro-Woolley North and Lyman 7.5-minute Quadrangles, Western Skagit County, Washington. Washington State Division of Geology and Earth Resources Open File Report 2000-1, June, 2000 (Dragovich, et al., 2000).*
  - *Soil Survey of Skagit County Area, Washington. United States Department of Agriculture-Soil Conservation Service (USDA SCS), October 389.*
- Water well records obtained from the Washington State Department of Ecology (Ecology).
- Ground water quality information for nearby public water systems, as made available by Skagit County and the Washington State Department of Health (WSDOH).
- Aerial photographs of the project site and vicinity.
- Maps and proposed project layout information provided by Wilson Engineering, LLC.

- Technical reports prepared for the site and nearby projects by various consultants including:

  - *Potential Wastewater Infiltration Evaluation, Upper Skagit Indian Reservation, Skagit County, Washington.* Associated Earth Sciences Inc., for Wilson Engineering LLC, dated February 20, 2008.

  - *Bow Hill Pumping Tests Report, Task 2c, Upper Skagit Indian Tribe, Bow Hill, Washington.* Shannon & Wilson, Inc., for the Upper Skagit Indian Tribe, dated October 1993.

  - *Preliminary Aquifer Protection Area Delineation, Bow Hill Reservation, Sedro-Woolley, Washington.* Shannon & Wilson, Inc., for the Upper Skagit Indian Tribe, dated December 1993.

  - *Final Draft, Bow Hill Aquifer Hydrogeologic Evaluation, Bow Hill Reservation, Sedro-Woolley, Washington.* Shannon & Wilson, Inc., for the Upper Skagit Indian Tribe, dated January 1994.

- Geologic/hydrogeologic information regarding the project site and vicinity presented in various technical journals.

In 1993 through 1994, Shannon & Wilson, Inc. explored subsurface conditions at the project site to determine if it would be possible to develop ground water resources for the proposed Skagit Valley Casino Resort. Shannon & Wilson installed and tested a deep production well (SW-1) located in the southwest portion of the project site (Figures 1 and 2). Well SW-1 was completed in a productive aquifer; however, the Tribe decided to utilize water provided by Skagit County PUD No. 1 instead of developing an independent public water system. We understand that SW-1 was abandoned shortly before the construction of the Skagit Valley Casino Resort. The subsurface soil and aquifer testing information developed during the installation of SW-1 was incorporated into our evaluation, where appropriate. Details of Shannon & Wilson's previous site evaluations are presented in the above-referenced reports.

1.3 Physical Setting

1.3.1 Project Location

The project site is located approximately 5 miles north of the City of Burlington and just east of I-5 and west of Highway 99 in Skagit County (Figure 1). The project site is an irregular-shaped parcel that encompasses approximately 170 acres. Bow Hill Road is located adjacent to the south boundary of the site, Old Highway 99 is located east of the site, and I-5 is located adjacent to the western site boundary (Figures 1 and 2). Several single-family homes are located just to the southeast of the project site. A *Thousand Trails* campground and relatively undeveloped property are located to the north of the site.

The project site is accessed from the south by Darrk Lane, and Harrington Road provides access to the interior of the site (Figure 2). An additional unpaved road off Old Highway 99 provides access to the northeastern portion of the project site. The unpaved road eventually connects with Harrington Road in the southeastern portion of the project site.

The Skagit Valley Casino Resort and associated paved parking lots and drainage ditches are located in the southwest portion of the project site (Photo 1). A paved parking area is located in the northwest corner of the site. A small maintenance building with an associated water supply well (DW-1) is located in the southeast portion of the project site (Figure 2). DW-1 is currently used as the water supply for the maintenance building. We also understand that a water-slide park is planned for the southern portion of the project site (Figure 2).

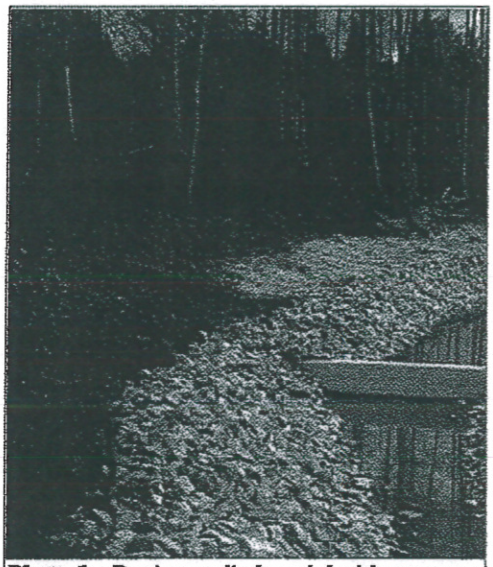


Photo 1. *Drainage ditch and deciduous trees in southwest portion of the project site.*

Most of the central, northern, and eastern portions of the site are generally undeveloped and covered with second- and third-growth deciduous and evergreen trees with a thick understory brush. Much of the south-central and southeastern portion of the site is covered with grassland and scattered deciduous and evergreen trees (Photo 1).

1.3.2 Physiography and Topography

The project site is located on the northern margin of the Samish River valley within what is generally referred to as the Puget Lowland. The Puget Lowland is a portion of a regional north-south trending topographic trough that extends from the Fraser River valley in British Columbia to northern Oregon.

The topography of the project site generally consists of a relatively flat, upland region that drops off steeply into the Friday Creek valley to the east and into the Samish River valley to the south of the project site (Figure 1). The upland portion of the project site is located at elevations ranging between roughly 260 and 300 feet above mean sea level (Figure 2). The Friday Creek and Samish River valleys are located at elevations that are generally less than 100 feet in the project vicinity. All elevations referenced in this report are relative to mean sea level unless otherwise noted.

The steep slopes located along portions of the eastern property boundary were measured at approximate inclinations of 50 to 65 percent, with a total relief of approximately 120 to 160 feet, dropping downward to elevations near 100 feet in the Friday Creek valley. The steep slopes located along the southern property boundary were measured at approximate

inclinations of 50 to 60 percent with a total relief of up to 180 feet to the Samish River valley (Figures 1 and 2).

1.3.3 Streams and Wetlands

Most of the upland area in the northern portion of the site appears to be covered with a complex series of shallow, interconnected wetlands. We were unable to identify any defined stream channels on the site. However, it appears that most of the surface water on the project site slowly migrates to the south and eventually discharges to the Samish River valley via a small stream channel located south of the site (Figure 1).

1.4 On- and Off-Site Water Supply Wells

1.4.1 General

We reviewed 64 water well reports obtained from an Ecology online database for wells located within an approximate 1.5-mile radius of the project site. We also obtained and reviewed water well reports for two on-site wells (DW-1 and SW-1). We were able to identify/locate five Public Water Systems (PWS) that use ground water wells within approximately 1 mile of the project site during our review of information made available by the Skagit County Health Department and the WSDOH. Copies of the water well reports reviewed for this project are presented in Appendix 1. The approximate locations of the PWS and water supply wells in the immediate vicinity of the project site are shown on Figure 1.

1.4.2 Off-Site Water Wells

The locations of the water supply wells in the immediate vicinity of the project site were determined based on location information presented on the water well reports. The elevations of the off-site wells were estimated based on land surface elevation presented on the USGS 7.5-minute topographic maps of the project vicinity. The subsurface information presented on the off-site water well reports was used to augment the on-site data in the preparation of the detailed evaluation of regional geologic/hydrogeologic conditions presented in this report.

Approximately 64 percent of the domestic wells completed in the vicinity of the project site are completed at depths below ground surface of greater than 100 feet. All depths reported in this report are relative to ground surface unless otherwise indicated. Roughly 56 percent of the wells have static water levels that are at depths greater than 100 feet (Appendix 1). Most of the water supply wells located in the upland area in the vicinity of the project site are relatively deep (greater than 100 feet) and produce less than 50 gallons per minute (gpm). Most of the wells located in the Friday Creek and Samish River valleys are less than 100 feet deep, and several of these wells produce more than 400 gpm (Appendix 1).

1.4.3 On-Site Wells

The location of DW-1 was field checked using site surveyed maps prepared by Wilson Engineering and a *Garmin* GPSmap 60Cx GPS unit. The wellhead elevation of DW-1 (281.71 feet) and ground surface elevation (280 feet) in the immediate vicinity of the well was surveyed by Wilson Engineering (Photo 2).

Photo 2. DW-1 wellhead.

The location of SW-1 was determined based on well location maps prepared by Shannon & Wilson. The ground surface elevation in the immediate vicinity of SW-1 (260 feet) was estimated based on the Shannon & Wilson location maps and site survey maps prepared by Wilson Engineering. A summary of the construction details for the on-site wells is presented in Table 1-1. A brief description of subsurface conditions encountered in the two on-site wells is provided in the following sections of this report.

Table 1-1
Summary of On-Site Well Construction Details

Well No.	Ground Surface Elevation (feet)	Total Depth of Boring (feet)	Well Open Interval Depth (feet)	Well Open Interval Elevation (feet)
MW-1	253.5	222.4	189.5	64.0
MW-2A	281.4	161.0	161.0	120.4
MW-2B	281.4	200.0	163.0	118.4
MW-3	263.7	195.0	186.0	77.7
DW-1	279.7	209.0	209.0	70.7
SW-1	260.0	360.0	179.0 – 194.0	66.0 – 81.0

Note: Elevations are relative to mean sea level and depths are relative to ground surface.

Domestic Well DW-1

The water well report for DW-1 indicates that Dahlman Pump & Drilling, Inc. drilled the well in March 1978 to a total depth of 290 feet. Six-inch-diameter casing was installed in the well to a depth of 209 feet (Appendix 1). The well encountered blue clay and gravel to a depth of approximately 75 feet. The clay/gravel unit was underlain by a sequence of sand and gravel with some clay to a depth of approximately 207 feet. The sand and gravel unit was underlain by fine sand to a depth of 250 feet which was underlain by blue clay to the total drilling depth of the well.

The depth to static water was measured in DW-1 at 200 feet (elevation 80 feet) on March 24, 1978, by the well driller (Appendix 1). The static water elevation in DW-1 ranged between roughly 78.7 feet and 79.9 feet, as measured by representatives of AESI during several site visits between March and August 2008. The well was reported to be able to produce 5 gpm with roughly 9 feet of water level drawdown during a bailer test conducted in 1978.

Shannon & Wilson Well SW-1

The water well report for SW-1 indicates that Hayes Drilling Inc., drilled the well in October 1993 to a total depth of 360 feet. Six-inch-diameter casing was installed in the well to a depth of approximately 358 feet (Appendix 1). The steel well casing was perforated between 179 and 194 feet.

The well encountered clay with some gravel to a depth of approximately 65 feet. The clay unit was underlain by a sequence of sand and gravel to a depth of approximately 195 feet. The sand and gravel unit was underlain by clay with some gravel interbeds to a depth of 285 feet. The clay unit was underlain by approximately 36 feet of clayey gravel, which was underlain by gray clay to the total drilling depth of the well.

Ground water was measured at a depth of approximately 179 feet (approximate elevation 81 feet) on October 7, 1993 (Appendix 1). Shannon & Wilson (1993) indicated that the well was capable of safely producing approximately 27 gpm with about 3.3 feet of total water level drawdown during a 24-hour aquifer test conducted on the well in October 1993. Shannon & Wilson (1993) concluded that SW-1 is "completed in a coarse-grained, high-transmissivity, unconfined aquifer."

1.4.4 Public Water System Wells

Most of the area in the immediate project vicinity, including the Skagit Valley Casino Resort and the private homes located immediately southeast of the site, are provided domestic water by the Skagit County PUD. However, there are four Group A and one Group B PWSs that use ground water wells located within an approximate 1-mile radius of the project site. Wellhead protection areas, as made available by the WSDOH, for the Group A PWS located in the vicinity of the project site are shown on Figure 1. It should be noted that none of the identified wellhead protection areas are located on the project site (Figure 1). The following sections provide a brief description of each system.

Burlington KOA – Water System ID 09535

The Burlington KOA PWS is located approximately 2,000 feet southeast of the project site (Figure 1). The Burlington KOA is a Group A transient non-community system that serves a total non-resident population of 250. The system has one active ground water well (Well 57, Figure 1) completed at depth of 37 feet.

We were able to locate a water well report for the Burlington KOA PWS well in Ecology's online database (Appendix 1). The KOA well was drilled by Radke Well Drilling in April and May 1976 (Appendix 1). The well encountered roughly 37 feet of gravel and sand, which was underlain by clay to the completion depth of the boring. The well was screened between depths of 32 and 37 feet. The static water level in the well was reported at a depth of approximately 6 feet by the well driller shortly after installation. Information presented on the water well report indicates that the well was able to produce 200 gpm with less than 2 feet of water level drawdown after 4 hours of pumping (Appendix 1).

The KOA well appears to be completed within a shallow unconfined aquifer located in the shallow alluvium fan and recent river alluvium associated with the Samish River. The shallow aquifer is likely in direct hydraulic continuity with Friday Creek and the Samish River. Information on file with the WSDOH indicates that the wellhead protection area for the system is circular in shape with a radius of approximately 1,000 feet (Figure 1).

Samish River Park – Water System ID 75670

The Samish River Park PWS is located approximately 5,000 feet south of the project site (Figure 1). The Samish River Park is a Group A community system that serves a total resident population of 227. The system has one active ground water well (Well 63, Figure 1) completed at a depth of approximately 45 feet.

We were able to locate a water well report for the Samish River Park PWS well in Ecology's online database (Appendix 1). The Park well was completed in August 1967 (Appendix 1). The well encountered gravel, silty gravel, and "hardpan" to the completion depth of the boring. The well was screened between depths of 35 and 45 feet. The static water level in the well was reported at a depth of approximately 15 feet by the well driller shortly after installation. Information presented on the water well report indicates that the well was able to produce 500 gpm with approximately 9 feet of water level drawdown after 4 hours of pumping (Appendix 1).

The Park well appears to be completed within a shallow unconfined aquifer located in the recent river alluvium associated with the Samish River. The shallow aquifer is likely in direct hydraulic continuity with Friday Creek and the Samish River. Information on file with the WSDOH indicates that the wellhead protection area for the Samish River Park well is a maximum of approximately 1,800 feet wide and extends roughly 2,000 feet up the Samish River Valley (Figure 1).

Samish State Salmon Hatchery – Water System ID 75677

The Samish State Salmon Hatchery Group B public water system well (Well 30) is located a few hundred feet east of the northeast corner of the project site and on the opposite side Friday Creek (Figure 1). According to WSDOH records, the well is currently used to provide domestic water to a resident population of eight at the State Salmon Hatchery.

The hatchery well was drilled by Dahlman Pump & Drilling in March 1978 (Appendix 1). The well encountered roughly 40 feet of gravel and sand, which was underlain by blue clay with fine sand lenses to a depth of roughly 150 feet. The well was screened between depths of 30 and 34.5 feet. The static water level in the well was reported at a depth of approximately 10 feet by the well driller shortly after installation. Information presented on the water well report indicates that the well was able to produce 27.5 gpm with approximately 9.5 feet of water level drawdown after four hours of pumping (Appendix 1).

The hatchery well appears to be completed within a shallow unconfined aquifer located in shallow alluvium deposits and is likely in direct hydraulic continuity with Friday Creek.

Skagit Speedways – Water System ID 07264

The Skagit Speedways Group A transient, non-community public water system wells are located approximately 3,500 feet north of the project site and on the opposite side of Old Highway 99 and Friday Creek (Figure 1). According to WSDOH records, there are three wells at the site that provide domestic water to a non-resident population of 3,971.

We were able to locate a water well report (Well 15, Figure 1) for one of the Speedways wells in Ecology's online database (Appendix 1). Well 15 was drilled by Hayes Drilling and Pumps in July through August 1972 (Appendix 1). The well encountered roughly 73 feet of clay overlying gravel and "hardpan" to a depth of roughly 110 feet. The gravel and "hardpan" unit was underlain by blue clay with sand and gravel to a depth of 127 feet. The clay was underlain by a water-bearing sand and gravel unit to a depth of 163 feet. The well was screened between depths of 153 feet and 162 feet. The static water level in the well was reported at a depth of approximately 119 feet by the well driller shortly after installation. Information presented on the water well report indicates that the well was able to produce 45 gpm with approximately 16 feet of water level drawdown after four hours of pumping (Appendix 1). WSDOH records indicate that the remaining two Speedways wells are completed in the immediate vicinity of Well 15 at depths of 157 feet and 164 feet.

The Skagit Speedways wells appear to be completed within a confined aquifer located within either Vashon advance outwash or pre-Vashon sediments. Information on file with the WSDOH indicates that the wellhead protection area for the Skagit Speedways wells is circular in shape with a radius of approximately 1,000 feet (Figure 1).

Thousand Trails Phase 2 – Water System ID 88123

The Thousand Trails Phase 2 Group A transient, non-community public water system well is located roughly 5,000 feet north of the project site (Figure 1). According to WSDOH records, there is one well at the site that provide domestic water to a non-resident population of 205. We were unable to locate a water well report for the Thousand Trail well in Ecology's online database (Appendix 1). However, the WSDOH records indicate that the well is approximately 200 feet deep.

The Thousand Trails well is likely completed within a confined aquifer located within either Vashon advance outwash or pre-Vashon sediments. Information on file with the WSDOH indicates that the wellhead protection area for the well is circular in shape with a radius of approximately 1,000 feet (Figure 1).

2.0 FIELD EXPLORATION METHODOLOGY

2.1 Field Investigations

AESI conducted several types of field exploration activities at the site for this project including: (1) reconnaissance of current site geologic/hydrogeologic conditions; (2) drilling four exploration borings completed as monitoring wells (MW-1, MW-2A, MW-2B and MW-3); (2) soil analytical testing; (3) infiltration testing in the monitoring wells; (4) ground water quality testing; and (5) ground water level monitoring in the on-site wells. The field investigation activities described in this report were performed between May and September 2008.

2.1.1 Geologic Reconnaissance

AESI investigated on-site surface geologic and hydrogeologic conditions by completing a reconnaissance of the site and surrounding area during several site visits conducted in May through August 2008. The geologic reconnaissance included a detailed inspection of the bluff face located to the east and south of the project site. Our reconnaissance, review of available information, and on-site explorations indicate that the area in the vicinity of the project site is generally underlain by a thick sequence of glacial and non-glacial sediments ranging in age between relatively recent alluvium to over 80,000 years before present (ybp).

The surficial geology of the project site and vicinity is described at a scale of 1:24000 in WDNR Open File Report 98-5 (Dragovich, et al., 1998). A surficial geologic map of the project site and immediate vicinity, based on the WDNR geologic map, is shown on "Geologic Map," Figure 3. A description of the geologic map units is presented on Figure 4, "Geologic Map Unit Descriptions." Two geologic cross sections (sections A-A' and B-B') depicting the inferred subsurface conditions beneath the site and vicinity are shown on "Generalized Geologic Cross Sections," Figure 5. The approximate locations of the cross sections are shown on Figures 1 and 2.

The oldest geologic unit encountered at the site is Olympia non-glacial sediments, consisting of silt and clay with some lenses of sand and gravel. The Olympia sediments are overlain by Vashon glacial sediments consisting of advance outwash sand and gravel and glacial till. The Vashon glacial till is overlain by Everson glaciomarine drift/fluvial outwash, and Sumas glacial sediments (Figures 3, 4 and 5). In the Friday Creek and Samish River valleys the glacial and non-glacial sediments are generally overlain by a thin cover of recent alluvium (Figures 3 and 5).

A more detailed discussion of the on-site geologic units and the geologic setting of the site and vicinity is presented in Section 3.0 of this report.

2.1.2 Exploration Borings/Monitoring Wells

AESI observed the drilling and construction of four monitoring wells (MW-1, MW-2A, MW-2B and MW-3) within the project site between May and August 2008. Drilling and well construction of the monitoring wells were performed by B&C Well Drilling and Pump Service, Inc. of Bellingham, Washington. The wells were drilled with a truck-mounted, air-rotary drill rig using a tri-cone drill bit and a casing shoe. Six-inch-diameter (6.625-inch outside-diameter) steel casing was used to drill and construct the wells.

An AESI geologist collected disturbed, but representative soil samples during drilling of the monitoring wells at approximately 5-foot intervals. The samples were placed in airtight, plastic bags and returned to our Kirkland, Washington, laboratory for further visual examination and testing, as necessary. During drilling, AESI personnel recorded pertinent information, including sample depths, stratigraphy, and ground water occurrence; and prepared drilling logs. Detailed descriptive logs of the sediments encountered and interpreted geologic units based on the field logs, drilling action, and inspection of the samples obtained, are presented in Appendix 2. The stratigraphic contacts shown on the boring logs represent the approximate boundaries between soil types; the actual transitions may be more gradual or abrupt. The ground water conditions depicted on the logs are only for the specific dates and locations reported, and therefore, are not necessarily representative of other locations and times.

Monitoring Well MW-1

Monitoring well MW-1 (Ecology Unique ID BAE189) was drilled to a total depth of 222.4 feet on May 28, 2008 (Table 1-1). Six-inch-diameter steel casing was extended to a depth of 189.5 feet where the well was completed as open-end casing (Appendix 2). The well was completed with an 18-foot bentonite surface seal and above grade monument (Photo 3). The elevations of the MW-1 wellhead and ground surface were determined by Wilson Engineering at 255.83 feet and approximately 253.5 feet, respectively.

***Photo 3.** MW-1 wellhead.*

The boring encountered a thin layer of silty topsoil over medium stiff brown to gray silt to a depth of approximately 30 feet. The brown to gray silt is interpreted to be Everson glaciomarine drift. The glaciomarine drift was underlain by a dense silty sand and gravel to a depth of approximately 60 feet. The dense silty sand and gravel is interpreted to be representative of Vashon glacial lodgement till. Approximately 125 feet of

medium to coarse grained sand and gravel with minor amounts of silt, interpreted to be Vashon glacial advance outwash, was encountered in MW-1 below the Vashon till unit (Figure 5, Appendix 2). The advance outwash was underlain by a silty fine sand to the completion depth of the boring. The silty fine sand is interpreted to Olympia non-glacial sediments.

The monitoring well was developed by air lift purging and hand bailing. Ground water was measured in the casing at a depth of approximately 158.68 feet (elevation 97.15 feet) shortly after the well was installed and developed.

Monitoring Wells MW-2A and MW-2B

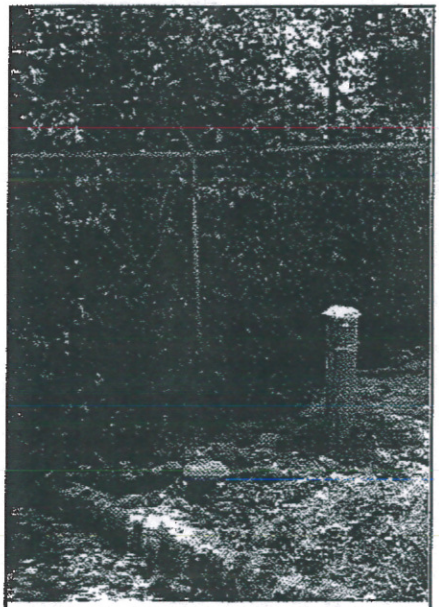


Photo 4. MW-2A and 2B wellheads.

Monitoring wells MW-2A (Ecology Unique ID BAE190) and MW-2B (Ecology Unique ID BAE193) were drilled to total depths of 161 feet and 200 feet, respectively, between May 29 and June 13, 2008. Six-inch-diameter steel casing was extended to a depth of 161 feet in MW-2A, where the boring met refusal on what appeared to be a layer of cobbles. The 6-inch-diameter steel casing was extended to a depth of 163 feet in MW-2B (Table 1-1). The wells were completed with 18-foot bentonite surface seals and above-grade monuments (Photo 4). The elevations of the MW-2A and MW-2B wellheads were determined by Wilson Engineering at 281.87 feet and 284.03 feet, respectively (Table 1-1). The ground surface in the vicinity of MW-2A and MW-2B is at an elevation of approximately 281 feet.

The borings encountered a thin layer of silty topsoil over medium stiff brown to gray silt to a depth of approximately 25 feet. The brown to gray silt is interpreted to be Everson glaciomarine drift. The glaciomarine drift was underlain by a dense silty sand and gravel to a depth of approximately 78 feet. The dense silty sand and gravel is interpreted to be representative of Vashon glacial lodgement till. Approximately 87 feet of medium to coarse-grained sand and gravel with minor amounts of silt, interpreted to be Vashon glacial advance outwash, was encountered in the borings below the Vashon till unit (Figure 5, Appendix 2). The advance outwash was underlain by a gray silt with clay to the completion depth of the boring. The silt/clay unit is interpreted to be Olympia non-glacial sediments.

Ground water was not encountered during the drilling or installation of both borings. Ground water also was not measured in either well casing during several occasions in June through September, 2008.

Monitoring Well MW-3

Photo 5. MW-3 wellhead.

Monitoring well MW-3 (Ecology Unique ID BAA564) was drilled to a total depth of 195 feet on August 8, 2008 (Table 1-1). Six-inch-diameter steel casing was extended to a depth of 186 feet where the well was completed as open-end casing (Table 1-1, Appendix 2). The well was completed with an 18-foot bentonite surface seal and above grade monument (Photo 5). The elevations of the MW-3 wellhead and ground surface were determined by Wilson Engineering at 266.42 feet and approximately 263.7 feet, respectively.

The boring encountered a thin layer of silty topsoil over medium-stiff, brown to gray silt to a depth of approximately 22 feet. The brown to gray silt is interpreted to be Everson glaciomarine drift. The glaciomarine drift was underlain by a dense silty sand and gravel to a depth of approximately 45 feet. The dense silty sand and gravel is interpreted to be representative of Vashon glacial lodgement till. Approximately 145 feet of medium- to coarse-grained sand and gravel with minor amounts of silt, interpreted to be Vashon glacial advance outwash, was encountered in MW-3 below the Vashon till unit (Figure 5, Appendix 2). The advance outwash was underlain by a very stiff to hard silt to the completion depth of the boring. The silt unit is interpreted to be Olympia non-glacial sediments.

The monitoring well was developed by air lift purging and hand bailing. Ground water was measured in the casing at a depth of approximately 182.02 feet (elevation 84.4 feet) shortly after the well was installed and developed.

2.1.3 Soil Testing

Soil samples collected from MW-1 and MW-2A at depths of 150 feet and 140 feet, respectively, were submitted to Northwest Agricultural Consultants of Kennewick, Washington, for analysis of cation exchange capacity. The soil sample collected at a depth of 150 feet in MW-1 has a cation exchange capacity of 3.1 meq. per 100 grams. The MW-2A soil sample has a cation exchange capacity of 2.6 meq. per 100 grams.

Soil samples obtained from MW-2B at depths of 175 feet and 190 feet were submitted to Beta Analytic for radiocarbon (C^{14}) age dating. The radiocarbon dating indicated an age of 38,570 +/- 450 ybp for the soil sample obtained from a depth of 175 feet in MW-2B and an age of 39,760 +/- 500 ybp for the sample collected at a depth of 190 feet. Copies of the cation exchange capacity and C^{14} age dating data sheets are included in Appendix 3.

2.1.4 Infiltration Testing

AESI completed three infiltration tests within two of the monitoring wells (MW-1 and MW-2A) between May 27 and May 30, 2008. The infiltration tests were completed concurrently with the drilling of the monitoring wells, while the casings were being advanced to their ultimate depths. The three infiltration tests were conducted through the open ends of the well casings at various depths within the unsaturated portion of the Vashon advance outwash formation. An approximately 3,100-gallon water truck was used for the infiltration tests, supplied by Jansma Construction, Inc. under subcontract to AESI.

The first infiltration test was conducted in MW-1 at a depth of approximately 124 feet. During this test, approximately 3,100 gallons of water were introduced into the casing over a 15-minute interval. We were unable to detect standing water in the well casing at the 10-minute mark following the conclusion of the infiltration test. The infiltration data indicates a conservative infiltration rate of roughly 124 gpm through the open end of the well casing (3,100 gallons/25 minutes) at a depth of 124 feet in MW-1.

The second infiltration test was conducted in MW-2A with the casing at a depth of approximately 95 feet. During the second test approximately 3,000 gallons of water were introduced into the casing over a 15 minute interval. We were unable to detect standing water in the well casing at the 8-minute mark following the conclusion of the infiltration test. The infiltration data indicates a conservative infiltration rate of roughly 125 gpm through the open end of the well casing (3,000 gallons/23 minutes) at a depth of 95 feet in MW-2A.

The third infiltration test was conducted in MW-2A with the casing at a depth of approximately 135 feet. During the third test, water was metered into the casing at a rate of approximately 6 gpm for 60 minutes. Roughly 10 feet of water head were measured in the casing at the end of the 60-minute test period. The water level in the casing declined to a total head of roughly 2 feet, approximately 15 minutes following the test.

2.1.5 Ground Water Quality Testing

A ground water sample was obtained from DW-1 on June 30, 2008 and submitted to Edge Analytical Laboratories of Burlington, Washington, for chemical analysis of primary and secondary drinking water parameters. Domestic well DW-1 was pumped at a rate of approximately 4 gpm for 15 minutes using the installed well pump prior to sampling. The samples were placed in properly labeled containers provided by the analytical laboratory and stored in a cooler for transport to the laboratory, in accordance with applicable chain-of-custody procedures. Copies of the laboratory data sheets, including chain-of-custody forms, are included in Appendix 4. A summary of the analytical results are presented in Table 2-1.

Iron and turbidity were detected at concentrations greater than the respective drinking-water secondary MCLs in the water sample obtained from DW-1 (Table 2-1). The remaining

primary and secondary parameters were either not detected or were detected at concentrations less than the appropriate primary and secondary MCLs (Appendix 4).

Table 2-1
Summary of On-Site Ground Water Chemistry

Well No.	Date	Iron[(1)] (mg/l)	Turbidity[(1)] (NTU)
DW-1	June 30, 2008	0.16	1.52
Maximum Contaminant Level		0.30	1.0

Notes:
(1) Secondary drinking water contaminant
Mg/l = milligrams per liter
NTU = Nephelmetric turbidity units

Table 2-2
Summary of Ground Water Elevations – On-Site Wells

Date	MW-1	MW-2A	MW-2B	MW-3	DW-1	SW-1
03/24/78	--	--	--	--	79.7[(1)]	--
10/07/93	--	--	--	--	--	80.0[(1)]
05/30/08	97.15	--	--	--	--	--
06/13/08	97.18	Dry	Dry	--	--	--
06/30/08	97.05	Dry	Dry	--	78.82	--
07/02/08	--	--	--	--	78.87	--
08/08/08	--	Dry	Dry	84.40	--	--
08/14/08	--	--	--	84.68	78.69	--
08/21/08	--	--	--	--	78.63	--
09/12/08	98.96	Dry	Dry	84.53	78.56	--

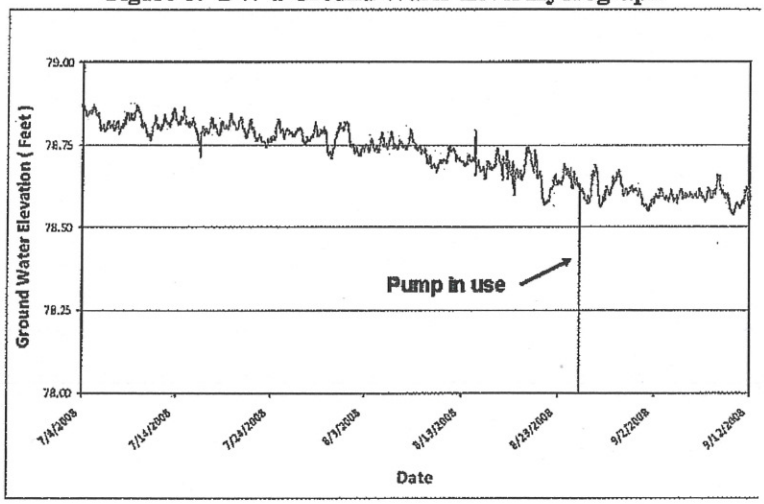
Notes:
(1) Measured by the water well driller
Elevations in feet are relative to mean sea level
-- indicates not measured

2.1.6 Ground Water Monitoring

Ground water levels in MW-1, MW-2A, MW-2B, MW-3 and DW-1 have been monitored periodically between May 30 and September 12, 2008, using an electric water level tape. Ground water has not been observed in MW-2A and MW-2B during this monitoring period. Ground water levels have been measured on an almost continuous basis in DW-1 since early July of 2008, using a pressure transducer/data logger system. The ground water level data were used to evaluate ground water flow direction and gradient in the aquifer that underlies the

project site. Ground water flow direction and other characteristics of the aquifer that underlie the project site are described in detail in Section 4.0 of this report. A summary of the hand-measured water levels in the on-site wells is shown in Table 2-2. A hydrograph of the ground water elevation in DW-1 is shown on Figure 6.

Figure 6. DW-1 Ground Water Level Hydrograph



Ground water levels have fluctuated less than 2 feet in the on-site wells (Table 2-2). Ground water elevations are generally around 97 to 98 feet near MW-1, 84 feet near MW-3 and 78 feet near DW-1. The hydrograph for DW-1 indicates that ground water levels have slowly declined between early July and late mid September 2008 (Figure 6). The lack of response to storm events observed in the DW-1 hydrograph data indicate that the aquifer that DW-1 is completed within is effectively isolated from the ground surface by the several tens of feet of low-permeability, glaciomarine drift and glacial till encountered in the on-site borings.

3.0 GEOLOGIC CONDITIONS

3.1 Regional Geology

The project site is situated adjacent to the Friday Creek/Samish River valley in what is generally considered to be the northern margin of the Skagit River drainage. The Skagit River extends from southern British Columbia south and westward into the Puget Lowland. The Puget Lowland is a portion of a regional, north-south trending topographic trough that extends from the Fraser River valley to northern Oregon. The Skagit and Samish River valleys are contained by steep mountains that rise above the valley bottoms to elevations greater than 4,000 feet in many locations. Bedrock is generally present at the ground surface above elevations of approximately 500 feet to the east of the project site. The mountains located to the east and northeast of the project site consist of a complex assemblage of volcanic, metamorphic, igneous, and sedimentary rocks. The valley bottom to the south and southwest of the project site is underlain by several tens and possibly hundreds of feet of glaciofluvial sediments and recent river alluvium. Relatively impermeable bedrock underlies the glaciofluvial/alluvium at depth.

Much of area in the vicinity of the project site is covered by several hundred feet of Quaternary sediments that were deposited during several glacial and non-glacial intervals that

occurred repeatedly during the past 2.4 million years in the low-lying region between the Cascade and Olympic mountains (Figures 3 and 5). During glacial periods, the southwestern margin of the Cordilleran Ice Sheet flowed southeastward from British Columbia into the Puget Lowland of western Washington (Blunt, et al., 1987).

Sediments from the most recent advancement of the Cordilleran Ice Sheet (Fraser Glaciation) are widely exposed at the surface in Island, Skagit, and Whatcom Counties and in the Puget Lowland. Sediments from older, non-glacial (Olympia and Whidbey) and glacial (Possession and Double Bluff) intervals underlie sediments of the Fraser Glaciation and are well exposed at the ground surface on many of the coastal bluffs in Island, Skagit, and Whatcom Counties. The limited number of exposures and similarities in depositional environments during each glacial and non-glacial episode make regional stratigraphic correlation difficult. However, a generalized stratigraphic framework for the surficial sediments has been established for much of the northern Puget Lowland (Dragovich and Stanton, 2007). Late Pleistocene stratigraphy and chronology (ages) of the geologic units that have been identified beneath the project site are briefly reviewed below.

3.1.1 Olympia Non-glacial Deposits

The Olympia non-glacial sediments (Qc_o) are widely distributed, but discontinuous in the Puget Lowland (Mullineaux, et al., 1965; Troost and Booth, 2007). The Olympia non-glacial sediments generally consist of thick deposits of organic silts, clays, silty sands, and fluvial sands and gravels. These sediments are interpreted to have been deposited in a meandering river environment (Dragovich and Grisamer, 1998). Olympia sediments were encountered in MW-1, MW-2B, MW-3, DW-1, and SW-1, completed at the project site (Figure 5).

Based on numerous radiocarbon (C^{14}) age dates, Olympia sediments are interpreted to range from approximately 20,000 to 60,000 ybp. Olympia-aged sediments greater than 45,000 ybp extend beyond the limits of conventional C^{14} dating. Olympia deposits correlate in part with the "transitional beds" of Booth (1990). The on-site Olympia-age deposits are described in greater detail in Section 3.2, "Project Site Geology."

Johnson and others (2001) indicate that the Olympia non-glacial sequence has a variable thickness (as thick as approximately 80 feet). In the western Skagit County area, Dragovich and Grisamer (1998) suggested that the Olympia beds are as thick as 160 feet.

3.1.2 Fraser Glaciation Sediments

The Fraser Glaciation consisted of multiple stades (episodes of glacial advance) and interstades (episodes of glacial retreat). The near-surface sediments located in western Skagit County and specifically at the project site are dominated by deposits of the Vashon stade, which represented the maximum advance of the Cordilleran Ice Sheet during the Fraser Glaciation; the Everson interstade, a period of glacial retreat; and the Sumas stade, a short interval of glacial advance.

Initial climatic cooling and growth of ice masses in British Columbia began as early as 30,000 ybp, but the ice maximum during the Vashon stade did not occur until approximately 14,000 to 15,000 ybp. At the maximum Vashon stade extent, the Puget lobe of the Cordilleran Ice Sheet extended a few miles south of Olympia, Washington. The ice is interpreted to have reached a thickness of about 4,000 to 5,000 feet near Bellingham and roughly 3,000 feet near Seattle, Washington. Retreat of the Vashon ice sheet was rapid, and deglaciation of the Puget Lowland was complete by approximately 11,300 ybp (Blunt, et al., 1987). The Vashon, Everson, and Sumas deposits encountered at the project site are described briefly here and in greater detail in Section 3.2, "Project Site Geology."

Vashon Advance Outwash

Several sediment types reflecting different depositional environments of the Vashon stade are exposed in the project vicinity (Figures 3, 4 and 5). The oldest Vashon stade sediments consist of silt, fine sand, and clay, which were deposited in proglacial, fluvial (river or stream), and lacustrine (lake) environments. Material derived from ice-free source areas may have also contributed sediment to these deposits and may also correlate in part with the "transitional beds" of Booth (1990).

Higher-energy glaciofluvial sands and gravels (advance outwash deposits [**Qga_v**]) accumulated in glaciofluvial environments (meltwater streams) that formed in front of the advancing Vashon glacier. The advance outwash deposits consist predominantly of moderate to dense deposits of sand and gravel with various amounts of silt. The advance outwash sediments were identified in all of the exploration borings completed for this study (Appendix 2, Figure 5). Advance outwash is also exposed on the slope face to the east and south of the project site (Figure 3)

Vashon Lodgement Till

As the Vashon glacier spread into the region, the advance outwash sediments were overrun and overconsolidated by approximately 4,000 to 5,000 feet of ice. Lodgement till (**Qgt_v**) was deposited at the base of, and subsequently overrun by, the advancing Vashon ice sheet. As a result, this material has been glacially consolidated into a dense condition. Lodgement till generally consists of a complex mixture of sand, gravel, and silt. Lodgement till was encountered in the monitoring well explorations completed at the project site. Till is also exposed at the ground surface on the slope located to the south and east of the project site (Figure 3).

Everson Glaciomarine Sediments

During late stages of deglaciation (12,500 to 10,000 ybp) the Cordilleran Ice Sheet thinned and retreated northward (Kovanen and Easterbrook, 2002). This period of ablation of the ice sheet is termed the Everson interstade (Armstrong, et al., 1965). The retreat of the Cordilleran Ice Sheet rapidly increased when the ice sheet vacated the Strait of Juan de Fuca around approximately 12,500 ybp and marine waters entered the Puget Lowland (Easterbrook, 1963,

1994). Shortly after the removal of the ice sheet from the Strait of Juan de Fuca, much of the retreating glacial ice in Skagit, Island and Whatcom Counties floated on the influx of marine waters. As the ice floated and/or retreated, it deposited a thick layer of glaciomarine sediments (Everson interstade sediments).

The glaciomarine sediments in the project vicinity include glaciomarine drift, fluvial-deltaic-turbiditic outwash, and emergence (beach) deposits (Dragovich and Grisamer, 1998; Dragovich and Stanton, 2007). Emergence beach deposits (**Qgom$_{ee}$**) are thought to be the product of ice-rafted rainout detritus, with a wave-washed mantle (Easterbrook, 1963, 1986). The beach deposits generally consist of loose, moderately to well sorted gravel and sand with local boulders, and are generally less than 25 feet thick (Lapen, 2000). We did not identify any emergence beach deposits on the project site.

The fluvial-deltaic glaciomarine outwash (**Qgom$_e$**) consists of loose sand and gravel with some interlayered silt and clay deposits by ice-marginal and sub-ice streams. We did not identify any fluvial-deltaic glaciomarine outwash on the project site.

The glaciomarine drift (**Qgdm$_e$**) was deposited from the melting of continental glaciers as they "floated" on seawater approximately 11,000 years ago. The glaciomarine drift contains a high percentage of fine-grained sediments and, consequently, has a very low permeability. The glaciomarine drift is typically an unsorted mixture of blue-gray, fossiliferous, pebbly silt and clay with till-like mixtures, marine clay, deltaic sand and gravel, and fluvial clay, silt, sand and gravel (Armstrong, et al., 1965; Easterbrook, 1963, and 1994). All four of the exploration borings completed for this project encountered a relatively thick deposit of glaciomarine drift, either at or near the ground surface (Figures, 3, 4 and 5).

Sumas Glacial Deposits

Sumas deposits in the immediate vicinity of the project site are deltaic sediments (**Qgod$_s$**) and fluvial sediments (**Qgo$_s$**). Both of these deposits generally consist of a complex mixture of sand, gravel, and cobbles, with some lenses of silt and clay. There are no Sumas deltaic or fluvial sediments located on the site. However, these units are located in the Friday Creek and Samish River valleys located south and east of the project site (Figures 2 and 3).

3.1.3 Holocene Non-glacial Deposits

Landslide, Alluvial Fan, and Alluvium

Recent sediments mapped within the project vicinity primarily consist of landslide deposits (**Qls**), alluvial fan deposits (**Qaf**), and alluvium (**Qoa, Qa$_s$, Qa**). The landslide deposits consist of poorly sorted and unstratified diamicton. A small historic landslide is located just to the east of the project site (Figures 3 and 4). Most of the Friday Creek valley immediately east of the project site and the area near the intersection of Friday Creek and the Samish River have been mapped as alluvial fan deposits. A relatively thin layer of recent alluvium is mapped at

the ground surface in most of the Samish River valley, located just to the south of the project site (Figures 3 and 4).

3.2 Project Site Geology

3.2.1 Summary

Geologic conditions at the project site were evaluated using: 1) data obtained from AESI's fieldwork for this project; 2) data obtained from previously completed evaluations of the site; and 3) our review of regional geologic maps and documents. The following sections describe the on-site geologic units that are shown on the accompanying cross sections.

3.2.2 Geologic Units

Olympia Non-glacial Deposits – Qc_o

Olympia non-glacial deposits were encountered in the on-site exploration borings completed by AESI for this project, with the exception of MW-2A, as well as DW-1 and SW-1 (Appendices 1 and 2). Well MW-2A was completed just above the Olympia sediments where the casing hit refusal (Appendix 2). The Olympia sediments were encountered at depths ranging between 165 feet in MW-2B and 250 feet in DW-1. Olympia sediments were also encountered in on-site wells DW-1 and in SW-1 at depths of 250 feet and 190 feet, respectively (Figure 5). The Olympia sediments generally consisted of hard to dense, damp to saturated, orange/yellow-brown, or light gray, massive silt with lenses of fine sand, sandy silt, and silty sand with few coarse sand or gravel. Organic material was present intermittently throughout the unit.

Subsurface information obtained from the exploration borings indicates that the upper surface of the Olympia sediments is gently undulating, sloping to the southeast, and ranging in elevation between approximately 30 feet near DW-1, and 110 feet near MW-2A and MW-2B. Elevation contours of the upper surface of the Olympia sediments at the project site are shown on "Elevation of the Top of Olympia Sediments." Figure 7.

The Olympia deposits were distinguished in the exploration borings from the overlying advance outwash by a significant increase in fine-grained material (silt/clay), the presence of organic material, and a subtle color change that included slight hues of orange and yellow. Maximum thickness of Olympia sediments in the project site is unknown, but likely exceeds 100 feet in the immediate project vicinity.

Olympia non-glacial deposits were deposited in relatively low-energy alluvial environments between 15,000 to 60,000 ybp (Troost and Booth 2007). The generally fine-grained nature, high organic content, and local interbeds of fine sand suggest a lacustrine (lake) depositional environment for the Olympia sediments observed at the project site. Radiocarbon dating (C^{14}) was performed on selected samples from on-site exploration boring MW-2B. The results of radiocarbon dating are summarized in Table 3-1. The radiocarbon dating indicated that the

soil samples obtained from MW-2B were deposited during the generally accepted Olympia-age range of 15,000 to 60,000 ybp (Table 3-1).

Table 3-1
Summary of Radiocarbon Age Dating – Monitoring Wells

Exploration	Sample Depth (feet)	Geologic Unit	C_{14} Age
MW-2B	175	Olympia	38,560 +/- 450
MW-2B	190	Olympia	39,750 +/- 500

Vashon Advance Outwash - Qga_v

Vashon advance outwash was encountered below the Vashon glacial till sediments and above the Olympia non-glacial deposits in MW-1, MW-2A, MW-2B, MW-3, DW-1 and SW-1 (Appendices 1 and 2, Figure 5). The advance outwash sediments consist of gray, medium dense to very dense sand and gravel containing variable amounts of disseminated silt. The coarse-grained Vashon advance outwash deposits accumulated in glaciofluvial environments (meltwater streams) that formed in front of the advancing Vashon-age glacier. As the Vashon-age glacier spread into the region, the advance outwash sediments were consolidated into a dense condition by 4 to 5 thousand feet of ice. Based on the subsurface conditions encountered in the on-site monitoring wells, DW-1 and SW-1, it appears that the advance outwash ranges in thickness beneath the project site from roughly 85 feet near MW-2A/MW-2B to approximately 175 feet near DW-1 (Appendices 1 and 2, Figure 5). It should be noted that the unsaturated portion of the advance outwash is the unit targeted for the injection of treated wastewater at the project site.

Vashon Glacial Till - Qga_t

Vashon glacial till was encountered above the advance outwash in all of the on-site monitoring wells. The till ranged in thickness in the on-site monitoring wells between roughly 23 feet in MW-3 and approximately 53 feet in MW-2A/B. The till unit is described as dense to very dense, gray, silty sand with gravel and some lenses of silt. No ground water was encountered in the till unit in the on-site borings (Appendix 2).

Everson Glaciomarine Deposits

Everson glaciomarine drift was encountered in all of the on-site borings, including DW-1 and SW-1. The glaciomarine drift is generally a medium-stiff, moist, brown to gray-blue silt with clay and occasional gravel. The glaciomarine drift overlies the Vashon glacial till and ranges in thickness between roughly 20 and 30 feet. The unit generally has a very low permeability due to the high silt and clay content.

4.0 HYDROGEOLOGIC CONDITIONS

4.1 Ground Water Occurrence and Distribution

4.1.1 General

Water is present in the pore spaces of soils and sediment throughout the project vicinity. This "ground water" is part of the continuous hydrologic cycle, which, in the natural state, begins with infiltration of precipitation and runoff (recharge) and ends with discharge to rivers, springs, streams, wetlands, and ultimately to the surrounding saltwater bodies.

Under natural conditions, ground water recharge and discharge may shift with climatic cycle, but remain in overall balance. Withdrawal of ground water by wells diverts a part of the ground water cycle, resulting in adjustments to natural recharge, discharge, or both.

Ground water under saturated conditions flows preferentially through materials with greater porosity and permeability, such as clean gravels and sands. Where geologic conditions limit discharge, ground water accumulates in permeable zones, which, if they can support production from wells, are termed "aquifers." The sustainability of wells, or the long-term aquifer capacity, depends both on the extent of the aquifer, its rate of recharge and natural discharge, and the amount of withdrawal by producing wells.

Based on the information reviewed, data presented on water well reports for the surrounding wells, and the information obtained from our on-site explorations, it appears that the project site and vicinity are underlain by a shallow perched aquifer located on top of the relatively low permeability glaciomarine drift, an unconfined aquifer located in the Vashon advance outwash, and a confined aquifer in deep, permeable portions of the Olympia sediments. An additional shallow, unconfined aquifer is located in the alluvial sediments of the Friday Creek and Samish River valleys located to the east and south of the site.

Although the research completed for this project did not indicate their presence, it is possible that other aquifers exist at depth beneath the project site or in the project vicinity. Water well reports for wells located in the vicinity of the site, subsurface conditions encountered in the on-site monitoring wells, and information presented on the log of SW-1 indicate that the deep confined Olympia aquifer is effectively separated from the unconfined advance outwash aquifer by almost 100 feet of low permeability clay (Appendix 1). Consequently, the deep aquifer is unlikely to be effected by the injection of treated wastewater into the unsaturated portion of the advance outwash above the unconfined aquifer. Therefore, the following sections of this report will specifically address potential impacts to the perched aquifer, the advance outwash aquifer, and the shallow alluvial aquifer, located in the Friday Creek and Samish River valleys, from the injection of wastewater at the project site.

4.1.2 Aquifers

Perched Aquifer

- A localized, shallow perched aquifer appears to have formed where precipitation has infiltrated through the 1 to 2 feet of relatively permeable topsoil/weathered glaciomarine drift soils and has encountered the top of low-permeability, unweathered glaciomarine drift and/or glacial till that appears to underlie the upland portion of the project site.

- The perched ground water appears to generally flow south and southeast toward the Friday Creek and Samish River valleys. It is also possible that some of the perched ground water in the very northern portion of the site flows off-site to the north and northeast. The perched aquifer flow direction is likely controlled by the topography of the top of the underlying glaciomarine drift/glacial till, which likely generally mimics the ground surface topography beneath the project site.

- The seasonal high ground water levels in the perched aquifer appear to be roughly 1 foot below the ground surface during the winter months of the year and likely 1 to 2 feet below the ground surface in the summer and late fall months.

- Recharge to the shallow perched aquifer is from the direct infiltration of precipitation.

- The perched aquifer is in continuity with and generally discharges to the abundant wetlands located on the upland portion of the site. The shallow aquifer likely also discharges in local areas to springs and seeps in the steep slope areas of the site.

- The perched aquifer may also provide some recharge to deeper aquifers located beneath the site by vertical infiltration. However, due to the relatively low permeability of the underlying glaciomarine drift and/or glacial till, it is our opinion that vertical recharge to deeper aquifers is relatively insignificant.

Advance Outwash Aquifer

- The advance outwash aquifer appears to be unconfined and wedge shaped, with the base of the aquifer being the top of the underlying low permeability Olympia sediments (Figure 5).

- The aquifer was encountered in MW-1, MW-3, DW-1, and SW-1. However, aquifer was not encountered in MW-2A and MW-2B, which indicates that the aquifer thins and eventually disappears to the northwest and west of the project site (Appendix 2, Figures 5 and 7).

- The saturated (aquifer) portion of the advance outwash appears to be a maximum of approximately 40 to 50 feet thick near the eastern and southern margins of the project site.

- Recharge to the advance outwash aquifer appears to be primarily from the limited vertical infiltration of water from the perched aquifer through the overlying low permeability glaciomarine drift and Vashon till.

- The ground water in the advance outwash flows to the south and slightly southeast beneath the project site and has a hydraulic gradient (slope) of 0.01, as shown on the "Ground Water Contour Map" of the advance outwash aquifer, Figure 8.

- The elevation of ground water in the advance outwash aquifer ranges between approximately 100 feet in the northern portion of the project site to less than 75 feet near the southern margin of the project site (Figure 8).

- The aquifer ultimately merges with a shallow alluvial aquifer located in the Friday Creek and/or Samish River valleys at elevations less than approximately 100 feet (Figure 8).

- Transmissivity is a measure of the amount of water that can be transmitted horizontally by the full saturated thickness of the aquifer under a hydraulic gradient (slope) of 1. Shannon & Wilson (1993) calculated a transmissivity value for the advance outwash aquifer that ranged between 3,600 square feet per day (ft^2/d) and 6,600 ft^2/d, based on their aquifer testing results for SW-1.

- Aquifer hydraulic conductivity is a measure of the rate at which water can move through an aquifer. Hydraulic conductivity is equal to the transmissivity divided by total aquifer thickness. The saturated thickness of the aquifer in the immediate vicinity of SW-1 is approximately 15 feet (Shannon & Wilson, 1993). Therefore, the aquifer hydraulic conductivity ranges between 240 feet per day (ft/d) and 440 ft/d.

- The average linear velocity of ground water in the advance outwash aquifer can be estimated by the product of the aquifer hydraulic conductivity, the hydraulic gradient, and the inverse of the aquifer porosity. Assuming an aquifer porosity of 0.25, a hydraulic gradient of 0.01, and an average hydraulic conductivity of 340 ft/d results in an average linear velocity of approximately 14 ft/d for ground water in the advance outwash aquifer that underlies the project site.

Shallow Alluvial Aquifer

- The alluvial aquifer is located at a depth of approximately 10 to 30 feet in the Friday Creek and Samish River valleys. The aquifer is overlain by several feet of lower-permeability alluvial fan and overbank sediments in local areas (Figure 3).

- The alluvial aquifer is likely at least several tens of feet thick, and it appears to co-mingle with the advance outwash aquifer, and possible with older deeper aquifers beneath the valley floor.

- Ground water in the alluvial aquifer flows generally to the south in the Friday Creek and Samish River valleys and ultimately discharges into either Friday Creek, Samish River and/or Padilla Bay.

- The ground water levels in the alluvial aquifer appear to be at depths ranging between approximately 4 and 10 feet, based on subsurface conditions encountered in the exploration pits completed in the far eastern portion of the site (AESI, 2008). Depths to static water level, recorded on the water well reports for wells completed in the alluvial aquifer generally ranged between 10 and 30 feet.

- Recharge to the alluvial aquifer is from vertical recharge of precipitation and ground water throughflow from the adjacent advance outwash aquifer and possibly deeper aquifers.

- The alluvial aquifer appears to have a relatively high hydraulic conductivity, based on well-yield data recorded on water well reports for wells completed in the aquifer (Appendix 1).

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Infiltration Potential

The results of our field exploration and data analyses indicate that the unsaturated portion of the advance outwash has a relatively high permeability and likely has the capacity to accommodate the injection of several hundred gpm of treated wastewater.

We understand that the wastewater treatment plant is proposed to be constructed in the northwest corner of the project site and that the treated wastewater (200,000 gpd) will be injected into the unsaturated portion of the Vashon advance outwash through one or more Class V UIC wells located in this same area (Figure 1). The effluent discharge from the Tribe's proposed wastewater treatment plant will have very low suspended solids and will generally meet drinking water quality standards and Class A reclaimed water standards. Because of the highly treated nature of the wastewater and the apparent high permeability of the advance outwash, it should be feasible to inject the wastewater treatment system effluent into the unsaturated portion of the advance outwash via UIC wells.

To further evaluate the potential to inject the treated wastewater in the northwest corner of the project site, we recommend that the Tribe install and test a pilot injection well. The pilot injection well should be approximately 140 feet deep and constructed in the manner shown on

Figure 9. It should be noted that the base of the injection well will be approximately 25 feet above the base of the advance outwash unit or underlying water table surface, whichever is higher.

Testing of the well should include injecting clean, potable water into the well at a rate of up to 200 gpm for at least 8 hours. We understand that it may be possible to obtain the testing water from a nearby fire hydrant, owned by the Skagit County PUD. Water levels should be monitored periodically in the injection well and in nearby wells MW-2A and MW-2B prior to, during, and following the injection test. Information gained during the well testing procedure will be used to evaluate the capacity of the advance outwash, and to estimate the number and spacing of injection wells needed to handle the predicted 200,000 gpd of treated wastewater.

5.2 Ground Water Mounding

We used a three-dimensional ground water flow model (USGS Modflow) to evaluate potential ground water mounding resulting from the infiltration of 200,000 gallons of treated wastewater per day in the northwest corner of the project site. Input to the ground water model is listed below:

Aquifer Hydraulic Conductivity	= 340 ft/d
Aquifer Hydraulic Gradient	= 0.01
Aquifer Porosity	= 0.25
Wastewater Infiltration Rate	= 200 gpm

The ground water model indicated that an approximate 4 foot-high ground water mound would develop immediately beneath the injection well. The ground water model also indicated that the ground water mound would decrease to less than 0.1 feet, approximately 1,000 feet downgradient and 850 feet upgradient of the injection well.

The previously described steep slopes that lead down into the Friday Creek and/or Samish River valleys are located more than 2,500 feet downgradient from the proposed injection well site. The ground water mounding analyses indicates that there should be an insignificant change in ground water levels near the steep slopes located to the east and south of the project site. It should also be noted that ground water levels near these slopes appear to be at elevations that are near or below the valley floor. Therefore, it appears that the proposed injection of 200,000 gpd of treated wastewater will not have a significant effect on the stability of steep slopes in the immediate vicinity of the project site.

5.3 Potential Impacts to Nearby Public Water Systems

As previously discussed, there are five public water systems located within approximately one mile of the project site. Two of these water systems (Thousand Trails and Skagit Speedways are located more than 4,000 feet hydraulically upgradient of the proposed injection well location. The Samish River Park and Burlington KOA PWS are located more than 5,000 feet

hydraulically downgradient of the proposed injection well location (Figure 1). The Samish State Salmon Hatchery PWS is located over 3,000 feet hydraulically cross gradient and across Friday Creek from the proposed injection well location (Figure 1).

Based on our data analyses, the hydrogeologic setting of the project area, the water quality of the treated wastewater effluent, and the distance between the identified PWS/domestic wells and the proposed injection well location; it is our opinion that there will be no impact on water quality or quantity in the public water system and domestic wells located within approximately one mile of the project site from the injection of 200,000 gpd of treated wastewater into the unsaturated portion of the Vashon advance outwash at the proposed injection well site.

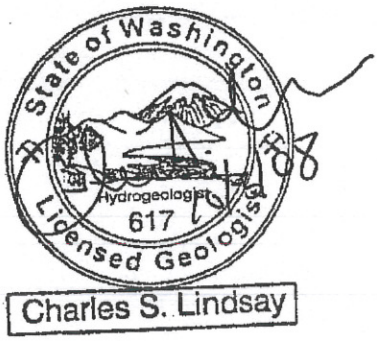
6.0 LIMITATIONS

We have prepared this report for the Upper Skagit Indian Tribe and their consultant, Wilson Engineering, LLC., for use in evaluating options for the disposal of treated wastewater at the project site. The conclusions and interpretations presented in this report should not be construed as a warranty of the subsurface conditions. Our conclusions and recommendations are based on a baseline of limited on-site information, and on information provided by various other consultants and the Tribe. Much analysis presented in this report is based on a limited number of explorations, and our experience has shown that soil and ground water conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations that may not be detected by a hydrogeologic study. If, during future site operations, subsurface conditions are encountered that vary appreciably from those described herein, AESI should be notified for review of the recommendations of this report and revisions of such, if necessary.

Within the limitations of scope, schedule, and budget, AESI attempted to execute these services in accordance with generally accepted professional principles in the field of hydrogeology at the time this report was prepared. No warranty, express or implied, is made.

We have enjoyed working with you on this study and are confident that the conclusions presented in this report will aid in the successful completion of your project. If you should have any questions or require further assistance, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Everett, Washington



Charles S. Lindsay, P.G., P.E.G., P.Hg.
Principal Geologist/Hydrogeologist

7.0 BIBLIOGRAPHY

Almasri, M., and Kaluarachchi, J., February 2004, Implications of ground nitrogen loading and soil transformations on ground water quality management, Journal of the American Water Resources Association, pp 165-186.

Armstrong, J, et al., 1965, Late Pleistocene stratigraphic chronology in southwestern British Columbia and northwestern Washington [abstract]: Geological Society of America Special Paper 82, p. 237.

Associated Earth Sciences, Inc., February 20, 2008, Potential wastewater infiltration evaluation, Upper Skagit Indian Reservation, Skagit County, Washington.

Benefield, L., Washington State Department of Health Technical Issue #7b-residential flow rates, May 2002.

Bidlake, W., Payne, K., 2001, Estimating recharge to ground water from precipitation at Naval Submarine Base Bangor and vicinity, Kitsap County, Washington, 33 p.

Bloom, A., 1978, Geomorphology, a systematic analysis of late Cenozoic landforms, Department of Geological Sciences, Cornell University.

Blunt, D., et al., 1987, Chronology of Pleistocene sediments in the Puget Lowland, Washington: Washington Division of Geology and Earth Resources Bulletin, v. 77, pp. 321-353.

Booth, D., 1990, Surficial geology of the Skykomish and Snoqualmie Rivers area, Snohomish and King Counties, Washington: U.S. Geological Survey Miscellaneous Investigations Map I-1745, scale 1:50,000.

Clements, E., and Otis, R., Environmental Protection Agency (EPA). 1980, design manual: on-site wastewater treatment and disposal systems, Report No. EPA-625/1-80-012. 390p.

Cleverdon, T., 1999, Datum Pacific, Personal Communication.

Cline, D., Jones, M., Dion, K., Whiteman, Sapik, D, 1982, Preliminary survey of ground-water resources for Island County, Washington, USGS OFR 82-561.

Department of Ecology, 2005, Ecology stormwater management manual for Western Washington.

Department of Ecology, 1979, Coastal Zone Atlas.

Dragovich, J., Gilberson, L., Norman, D., Anderson, G., Petro, G., 2005, Geologic map of the Utsalady and Conway 7.5-minute Quadrangles, Skagit, Snohomish, and Island Counties, Washington, OFR 2002-5.

Dragovich, J., Grisamer, C., 1998, Quaternary stratigraphy, cross sections, and general geohydrologic potential of the Bow and Alger 7.5-minute quadrangles, western Skagit County, Washington: Washington Division of Geology and Earth Resources Open File Report 98-8, 29 p., 6 pl.

Dragovich, J., Grisamer, C., 1998, Geologic map and interpreted geologic history of the Bow and Alger 7.5 minute quadrangles, western Skagit County, Washington: Washington Division of Geology and Earth Resources Open File Report 98-5, 80 p., 3 pl.

Dragovich, J., Norman, D., Lapen, T., Anderson, G., 1999, Geologic Map of the Sedro Woolley North and Lyman 7.5-minute Quadrangles, Western Skagit County, Washington, OFR 99-3.

Dragovich, J., Norman, D., Anderson, G., 2000, Interpreted Geologic History of the Sedro-Woolley North and Lyman, 7.5-minute Quadrangles, Western Skagit County, Washington, OFR 2000-1.

Dragovich, J., Stanton, B., 2007, The Darrington-Devils Mountain Fault-A probably active reverse-oblique-slip fault zone in Skagit and Island Counties, OFR 2007-2.

Dragovich, J., March 2008, Personal communication.

Driscoll, F., 1986, Groundwater and Wells, Johnson Filtration Systems Inc., St. Paul Minnesota.

Dunne, T., Leopold, L., 1978, Water in environmental planning, W.H. Freeman and Company, New York.

Easterbrook, D., 1962, Pleistocene geology of the northern part of the Puget Lowland, Washington: University of Washington Doctor of Philosophy thesis, 160 p.

Easterbrook, D., 1963a, Late Pleistocene glacial events and relative sea-level changes in the northern Puget Lowland, Washington: Geological Society of America Bulletin, v. 74, no. 12, p.1465-1483.

Easterbrook, D., 1963b, Vashon glaciation and late Wisconsin relative sea-level changes in the northern part of the Puget Lowland, Washington: Geological Society of America Special paper 73, p. 37.

Easterbrook, D., 1969, Pleistocene chronology of the Puget Lowland and San Juan Islands, Washington: Geologic Society of America Bulletin, v. 80, no 11, p. 2273-2286.

Easterbrook, D., and Anderson, H. Jr., 1986, Part I. Pleistocene stratigraphy and groundwater resources of Island County: Washington Department of Water Resources Water-Supply Bulletin 25, p. 1-34.

Easterbrook, D., and Anderson, H. Jr., 1986, Part II. Pleistocene stratigraphy and groundwater resources of Island County: Washington Department of Water Resources Water-Supply Bulletin 25, p. 22-53.

Easterbrook, D., 1994, Chronology of pre-late Wisconsin Pleistocene sediments in the Puget Lowland, Washington. In Lasmanis, Raymond, Cheney, E.S., Convenors, Regional geology of Washington State: Washington Division of Geology and Earth Resources Bulletin 80, p. 191-206.

Eisses, D., 2006, Birch Bay Water and Sewer District, Personal Communication.

Finnemore, E., November-December 1993, Estimation of ground-water mounding beneath septic drain fields, Ground Water, Vol. 31, No. 6, pp 884-889.

Flint, F., 1957, Glacial and Pleistocene Geology, Yale University.

Freeze, R., Cherry, J., 1979, Groundwater, Prentice Hall, Inc., Englewood Cliffs, New Jersey.

Geng, Q., Girard, G., and Ledoux, E., Mar.-April 1996, Modeling of nitrogen cycle and nitrate transfer in regional hydrogeologic systems, Ground Water, Vol. 34, No. 2, pp 293-304.

Hantche, N., Finnemore, E., July-August 1992, Predicting ground-water nitrate-nitrogen impacts, Ground Water, Vol. 30, No. 4, pp 490-499.

Hitt, G., 2008, Gene's Well Drilling, Personal communication.

Johnson, S., Dadisman, S., Mosher, D., Blakely, R., Childs, J., February 2001, Active tectonics of the Devils Mountain Fault and related structures, Northern Puget Lowland and Eastern Strait of Juan de Fuca Region, Pacific Northwest, USGS Professional Paper 1643.

Jones, M., 1985, Occurrence of ground water and potential for seawater intrusion, Island County, Washington, WRIR 85-4046.

Kahle, S., and Olsen, T., 1995, Guemes Island Environmental Trust and Skagit County Conservation District, hydrogeology and quality of ground water on Guemes Island, Skagit County, Washington, USGS WRIR Report 94-4236.

Kovanen, D., and Easterbrook, D., 2002, Radiocarbon reservoir values for late Pleistocene marine shells in the Fraser Lowland of western north America.

Lapen, Thomas J., Geologic Map of the Bellingham 1:1000,000 Quadrangle, Washington, Department of Natural Resources, OFR 2000-5.

Mayer, P., DeOreo, W., 2001, Residential End Uses of Water: American Water Works Association Research Foundation.

Metcalf, Eddy, 1991, Wastewater engineering: treatment, disposal and reuse, Third Edition, McGraw-Hill Inc., Boston, Massachusetts.

Materials Testing & Consulting, Inc., March 13, 2006, Geohazard assessment, Anderson Development, Camano Island, Washington.

Mullineaux, D., et al., 1965, Stratigraphy and chronology of late interglacial and early Vashon glacial time in the Seattle area, Washington: U.S. Geological Survey Bulletin 1194-O, 10p.

Northwest HydroGeo Consultants (NHGC), December 13, 2006, Hydrogeologic investigation for the Anderson Property: North Point, prepared for Design Northwest Architects.

Pacific Groundwater Group (PGG), November 2000a, Groundwater sampling and analysis plan for Brentwood PRD (Phases 1 and 3) large on-site septic system, prepared for Sea-Air Land Development Co.

Pacific Groundwater Group (PGG), January 2000b, Hydrogeologic report Maple Grove Drainfield Brentwood PRD, Camano Island Washington, prepared for Kreig Construction Air, Sea and Land Company.

Pessl, F., Jr.; Dethier, D.; Booth, D., Minard, J. P., 1989, Surficial geologic map of the Port Townsend 30- by 60-minute Quadrangle, Puget Sound region, Washington.

Robertson, W, Cherry, J., Jan-Feb. 1995, In situ denitrification of septic-system nitrate using reactive porous media barriers: field trials, Ground Water, Vol. 33, No. 1. pp 99-111.

Robertson, W, Cherry, J., Sudicky, E., Jan-Feb.1991 Ground-water contamination from two small septicsystems on sand aquifers, Ground Water, Vol. 29, No.1, pp 82-92.

Sapik, D., Bortleson, G., Drost, B., Jones, M., Prych, E., 1988, Ground-water resources and simulation of flow in aquifers containing fresh water and seawater, Island County, Washington, USGS WRIR 87-4182.

Shannon & Wilson, Inc., Preliminary Aquifer Protection Area Delineation, Bow Hill Reservation, Sedro-Woolley Washington, December 1993.

Shannon & Wilson, Inc., Final Draft Bow Hill Aquifer Hydrogeologic Evaluation, Bow Hill Reservation, Sedro-Woolley, Washington, January 1994.

Shannon & Wilson, Inc., Bow Hill Pumping Tests Report Task 2c, Upper Skagit Indian Tribe, Bow Hill, Washington, October 1993.

Soil Survey of Skagit County Area, Washington, Soil Conservation Service, United States Department of Agriculture, 1989.

Solley, W., Peirce, R. and Perlman, H., 1993, Estimated use of water in the United States in 1990. USGS Circular 1081.

Stoffel, K., 1980, Stratigraphy of Pre-Vashon quaternary sediments applied to the evaluation of a proposed major tectonic structure in Island County, Washington, USGS OFR 81-292.

Starr, R., and Gillham, R., Nov.-Dec. 1993, Denitrification and organic carbon availability in two aquifers, Ground Water, Vol. 31, No. 6, pp 934-947.

Sumioka, S., Bauer, H., , 2003, Estimating ground-water recharge from precipitation on Whidbey and Camano Islands, Island County, Washington, Water Years 1998 and 1999, USGS WRIR 03-4101.

Tesoriero, A., and Voss, F., Nov.-Dec. 1997, Predicting the probability of elevated nitrate concentrations in the Puget Sound Basin: implications for aquifer susceptibility and vulnerability, Ground Water, Vol. 35, No. 6, pp 1029-1039.

Thomas, B., Wilkinson, J., and Embrey, S., 1997, Snohomish County, Public Utilities District No. 1 of Snohomish County and Washington State Department of Ecology, The ground-water system and ground-water quality in western Snohomish County, Washington, USGS WRIR 96-4312.

Troost, K., Booth, D., June 1, 2007, Quaternary geology of the Central Puget Sound Lowland. presentation to Associated Earth Sciences, Inc.

US Department of Commerce, May 2001, US Census Bureau, 2000 census of population and housing, Washington State.

US Environmental Protection Agency, 1980, Design manual: on-site wastewater treatment and disposal systems, Report No. EPA-625/1-80-012.

Vaccaro, J., Hansen, A., Jones, M., 1998, Hydrogeologic framework of the Puget Sound aquifer system, Washington and British Columbia, USGS Professional Paper 1424-D.

Wilcox, J., Bradbury, K., Thomas, C., and Bahr, J., Nov.-Dec. 2005, Assessing background ground water chemistry beneath a new unsewered subdivision, Ground Water, pp 787-795.

Wilhelm, S., Schiff, S., and Cherry, J., Nov.-Dec.1994, Biogeochemical evolution of domestic waste water in septic systems: 1. conceptual model, ground water, Vol. 32, No. 6, pp 905-916.

Wilhelm, S., Schiff, S., and Cherry, J., Sept.-Oct.1994, Biogeochemical evolution of domestic waste water in septic systems: 2. application of conceptual model in sandy aquifers, Ground Water, Vol. 34, No. 5, pp 853-864.

APPENDIX 2

Monitoring Well Logs

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-1	1 of 5

Project Name	Upper Skagit/Deep Infiltration	Location	Skagit County, WA
Elevation (Top of Well Casing)	255.83'	Surface Elevation (ft)	253.46'
Water Level Elevation	93.33'	Date Start/Finish	5/27/08,5/28/08
Drilling/Equipment	Air Rotary	Hole Diameter (in)	6"
Hammer Weight/Drop	Grab samples		

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
						Topsoil Medium dense, moist, brown, SILT, with sand.
						Everson Glaciomarine Drift Medium stiff, moist, brown, SILT, with sand and gravel, frequent cobbles.
5						
						Decreasing sand and gravel.
10						Grades to hard.
15						
20						Grades to gray.
25						
						Vashon Glacial Till? Dense, moist, gray, SAND and GRAVEL, with silt.
30						
35						
40						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

Water Level (5/30/08)

Water Level at time of drilling (ATD)

Logged by: EG

Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-1	2 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 255.83'
Water Level Elevation: 93.33'
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 253.46'
Date Start/Finish: 5/27/08,5/28/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
50						Medium stiff, moist, dark gray to black, SILT, with trace sand and possible organics.
55						Dense, moist, gray, silty SAND, with gravel.
60						**Vashon Glacial Outwash** Medium dense, moist, gray, fine to coarse SAND, with gravel and silt.
65						
70						Dense, moist, brown-gray, fine to coarse SAND, with gravel.
75						
80						
85						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level (5/30/08)
Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-1	3 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 255.83'
Water Level Elevation: 93.33'
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 253.46'
Date Start/Finish: 5/27/08,5/28/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
95						
100						
105						
110						
115						
120						
125						
130						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

- Water Level (5/30/08)
- Water Level at time of drilling (ATD)

Logged by: EG

Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-1	4 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 255.83'
Water Level Elevation: 93.33'
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 253.46'
Date Start/Finish: 5/27/08,5/28/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
140						
145						
150						Sample MW-1 collected for cation analysis. Cation exchange capacity (3.1 meq/100g).
155	▽	Ground water level on 5/30/08				Dense, moist, gray, fine to coarse SAND.
160						
165						Grades to wet.
170						
175	▼					

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
▽ Water Level (5/30/08)
▼ Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-1	5 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 255.83'
Water Level Elevation: 93.33'
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 253.46'
Date Start/Finish: 5/27/08,5/28/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/6"	Graphic Symbol	DESCRIPTION
185						**Olympia Non-Glacial Sediments** Medium dense, wet to saturated, silty fine SAND, trace gravel (silt interbeds?) interbedded with silt.
190		Bottom of 6" diameter steel casing at 189.5'				
195						
200						
205						
210						
215						
220						Boring terminated at 220 feet on 5/28/08 BOH read at 222.4'

Sampler Type (ST):
- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level (5/30/08)
Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-2A	1 of 4

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 281.87'
Water Level Elevation:
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 281.42'
Date Start/Finish: 5/29/08,5/30/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/6"	Graphic Symbol	DESCRIPTION
						Brown Topsoil
						Everson Glaciomarine Drift Medium stiff, moist, brown, SILT.
5						
10						
15						Grades to gray.
20						Medium stiff to stiff, moist, gray, SILT, with sand and gravel.
25						**Vashon Glacial Till** Dense, moist to wet, gray, gravelly silty SAND, with interbeds of sandy silt.
30						
35						
40	▼					

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-2A	2 of 4

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 281.87'
Water Level Elevation:
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 281.42'
Date Start/Finish: 5/29/08,5/30/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
50						
55						Decreasing gravel content.
60						
65						
70						
75						
80						**Vashon Glacial Outwash** Dense, moist, gray, fine to coarse SAND, with gravel.
85						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-2A	3 of 4

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 281.87'
Water Level Elevation:
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 281.42'
Date Start/Finish: 5/29/08,5/30/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
95						Dense, moist, gray, fine to coarse SAND, trace gravel.
100						
105						
110						
115						Dense, moist, gray, dense to coarse SAND, with gravel.
120						
125						
130						

Sampler Type (ST):
- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-2A	4 of 4

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 281.87'
Water Level Elevation:
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 281.42'
Date Start/Finish: 5/29/08,5/30/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
140						Sample MW-2 obtained for cation exchange capacity (2.6 meq/100g).
145						
150						
155						
160		Bottom of 6" diameter steel casing at 161'				SAND and GRAVEL, trace silt. Cobble encountered at 160'.
						Boring terminated at 161 feet on 5/30/08
165						
170						
175						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-2B	1 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 284.03'
Water Level Elevation:
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 281.42'
Date Start/Finish: 5/29/08,5/30/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
0						**Everson Brown Topsoil**
						Glaciomarine Drift
						Medium stiff, moist, brown, SILT.
5						
10						
15						
						Grades to gray.
20						
						Medium stiff to stiff, moist, gray, SILT, with sand and gravel.
25						**Vashon Glacial Till**
						Dense, moist to wet, gray, gravelly silty SAND, with interbeds of sandy silt.
30						
35						
40	▼					

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: EG

Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-2B	2 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 284.03'
Water Level Elevation:
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 281.42'
Date Start/Finish: 5/29/08,5/30/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
50						
55						Decreasing gravel content.
60						
65						
70						
75						
						Vashon Glacial Outwash
80						Dense, moist, gray, fine to coarse SAND, with gravel.
85						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-2B	3 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 284.03'
Water Level Elevation:
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 281.42'
Date Start/Finish: 5/29/08,5/30/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
95						Dense, moist, gray, fine to coarse SAND, trace gravel.
100						
105						
110						
115						Dense, moist, gray, dense to coarse SAND, with gravel.
120						
125						
130						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-2B	4 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 284.03'
Water Level Elevation:
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 281.42'
Date Start/Finish: 5/29/08,5/30/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
140						
145						
150						
155						
160						Moist to wet, brown, fine to medium SAND and GRAVEL, with silt and cobbles.
165		Bottom of 6" diameter steel casing at 163'				**Olympia Non-Glacial Sediments** Gray, SILT/CLAY.
170						
175			C			C^{14} age-dating sample 38,570+/- 450 YBP

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-2B	5 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 284.03'
Water Level Elevation:
Drilling/Equipment: Air Rotary
Hammer Weight/Drop: Grab samples

Location: Skagit County, WA
Surface Elevation (ft): 281.42'
Date Start/Finish: 5/29/08,5/30/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
185						
190						C^{14} age-dating sample 39,760+/- 500 YBP
195						
200						Boring terminated at 200 feet on 5/30/08
205						
210						
215						
220						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: EG
Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/9/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-3	1 of 5

Project Name	Upper Skagit/Deep Infiltration	Location	Skagit County, WA
Elevation (Top of Well Casing)	266.42'	Surface Elevation (ft)	263.72'
Water Level Elevation	84.68'	Date Start/Finish	8/7/08,8/8/08
Drilling/Equipment	B&C Well Drilling/Air Rotary	Hole Diameter (in)	6"
Hammer Weight/Drop	140# / 30"		

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
						Brown topsoil.
						Everson Glaciomarine Drift
5						Medium stiff to stiff, moist, gray, SILT, slightly mottled.
10						Grades to brownish gray, trace fine gravel (subround).
15						Driller adds water, as above.
						At 18' grades to stiff, moist, bluish gray, SILT.
20						**Vashon Glacial Till**
						At 22' becomes dense, moist, gray, SAND and GRAVEL (subround), few silts.
25						
30						Grades to dense, moist, grayish blue silty SAND, with gravel (subround).
35						As above.
40						At 39' grades to dense, moist, grayish brown, silty GRAVEL (subround), few fine to coarse sand.

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

Water Level (8/14/08)

Water Level at time of drilling (ATD)

Logged by: JH

Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-3	2 of 5

Project Name	Upper Skagit/Deep Infiltration	Location	Skagit County, WA
Elevation (Top of Well Casing)	266.42'	Surface Elevation (ft)	263.72'
Water Level Elevation	84.68'	Date Start/Finish	8/7/08,8/8/08
Drilling/Equipment	B&C Well Drilling/Air Rotary	Hole Diameter (in)	6"
Hammer Weight/Drop	140# / 30"		

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
						Vashon Glacial Outwash Dense, moist, brown to brownish gray, GRAVEL (subround to round), few to little fine to coarse sand, trace silt.
50						As above.
55						At 54' grades to medium dense to dense, moist, grayish brown, fine to medium SAND, few gravel (subround to round), trace to few silt.
						At 57' grades to medium dense to dense, moist, grayish brown, fine to coarse SAND, with gravel (subround to round), trace silt.
60						
65						As above.
70						Grades to medium dense to dense, moist, grayish brown, medium to coarse SAND, few to little fine gravel (subround to round).
75						Grades to medium dense to dense, moist, grayish brown, fine to coarse SAND, little gravel (subround to round).
80						As above.
						At 83' grades to medium dense to dense, moist, brownish gray, SAND and GRAVEL (subround to round).
85						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

Water Level (8/14/08)

Water Level at time of drilling (ATD)

Logged by: JH

Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-3	3 of 5

Project Name: Upper Skagit/Deep Infiltration
Elevation (Top of Well Casing): 266.42'
Water Level Elevation: 84.68'
Drilling/Equipment: B&C Well Drilling/Air Rotary
Hammer Weight/Drop: 140# / 30"

Location: Skagit County, WA
Surface Elevation (ft): 263.72'
Date Start/Finish: 8/7/08,8/8/08
Hole Diameter (in): 6"

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
						Grades to medium dense to dense, moist, brownish gray, GRAVEL (subround to round), few fine to coarse sand.
95						Grades to medium dense to dense, moist, brownish gray, fine to coarse SAND, little gravel (subround to round).
100						As above.
105						Grades to medium dense to dense, moist, brownish gray, fine to medium SAND, few gravel (subround to round), trace silt.
110						Grades to medium dense to dense, moist, brownish gray GRAVEL (subround to round), little fine to coarse sand.
115						As above.
120						Grades to medium dense to dense, moist, grayish brown, fine to medium SAND, few to little gravel (subround to round), trace silt.
125						At 123' grades to medium dense to dense, moist, brownish gray, GRAVEL (subround to round), few to little fine to coarse sand. As above.
130						Grades to medium dense to dense, moist, grayish brown, fine to medium SAND, with gravel (subround to round), trace silt.

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

- Water Level (8/14/08)
- Water Level at time of drilling (ATD)

Logged by: JH

Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

Associated Earth Sciences, Inc.

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
EH080149A	MW-3	4 of 5

Project Name	Upper Skagit/Deep Infiltration	Location	Skagit County, WA
Elevation (Top of Well Casing)	266.42'	Surface Elevation (ft)	263.72'
Water Level Elevation	84.68'	Date Start/Finish	8/7/08,8/8/08
Drilling/Equipment	B&C Well Drilling/Air Rotary	Hole Diameter (in)	6"
Hammer Weight/Drop	140# / 30"		

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
140						Grades to medium dense to dense, moist, brownish gray, fine to medium SAND, few to little gravel (subround to round), trace to few silt.
145						As above, grades to grayish brown to brown.
						At 147' grades to orangish brown.
150						At 149' grades to medium dense to dense, moist, gray, fine to medium SAND, little gravel (subround to round), few silt.
155						At above.
160						Grades to medium dense to dense, moist, brownish gray, fine to medium SAND, little gravel (subround to round), trace to few silt.
165						As above.
170						Grades to medium dense, moist, gray to grayish brown, GRAVEL (subround to round), with fine to medium sand, trace to few silt.
175	▼					As above, very moist to wet.
	▽	Ground water level on				

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

▽ Water Level (8/14/08)

▼ Water Level at time of drilling (ATD)

Logged by: JH

Approved by:

NWWELL 080149A.GPJ BORING.GDT 9/8/08

APPENDIX 3

Soil Analytical Data

Northwest Agricultural Consultants
2545 West Falls
Kennewick, WA 99336
(509) 783-7450 Fax: (509) 783-5305

PAP-Accredited NAPT 2008

ASSOCIATED EARTH SCIENCE
911 FIFTH AVE. SUITE 100
KIRKLAND, WA 98033

Client No.: 1297B Date Received: 06-19-2008
Report No.: 12098 Page: 1 of 2
ea86e6-36324

Grower | Sampler | Field No. | Field Name **MW-1-S-30-150** | Crop Year | Crop | Yield Goal

Depth (ft.)	Available Inches	NO3-N lbs/acre	NH4-N lbs/acre	Sulfur ppm	pH	Soluble Salts (mmhos/cm)	Organic Matter Percent	P(bic) ppm	K(bic) ppm	P(ace) ppm	K(ace) ppm	Calcium (meq. per 100 grams)	Magnesium (meq. per 100 grams)	Sodium (meq. per 100 grams)	Eff.	Boron ppm	Zinc ppm	Manganese ppm	Iron ppm	Copper ppm	CEC (meq. per 100 grams)	% Base Sat.	Chloride lbs. per. acre	Bray 1P ppm	Total Bases (meq. per 100 grams)
1																									
Total	0.00																				3.1				

Estimated Nitrogen Release from Organic Matter

Estimated Total Nitrogen Available to Crop

Last Year's Crop

Fertilizer

Comments

Northwest Agricultural Consultants
2545 West Falls
Kennewick, WA 99336
(509) 783-7450 Fax: (509) 783-5305

PAP-Accredited NAPT 2008

ASSOCIATED EARTH SCIENCE
911 FIFTH AVE. SUITE 100
KIRKLAND, WA 98033

Client No.: 1297B Date Received: 06-19-2008
Report No.: 12098 Page: 2 of 2
e0728d-82001

Grower	Sampler	Field No.	Field Name	Crop Year	Crop	Yield Goal
			MW-2-S-28-140			

Depth (ft.)	Available Inches	NO3-N lbs/acre	NH4-N lbs/acre	Sulfur ppm	pH	Soluble Salts (mmhos/cm)	Organic Matter Percent	P(bic) ppm	K(bic) ppm	P(ace) ppm	K(ace) ppm	Calcium (meq. per 100 grams)	Magnesium (meq. per 100 grams)	Sodium (meq. per 100 grams)	Eff.	Boron ppm	Zinc ppm	Manganese ppm	Iron ppm	Copper ppm	CEC (meq. per 100 grams)	% Base Sat.	Chloride lbs. per. acre	Bray 1P ppm	Total Bases (meq. per 100 grams)
1																									
Total	0.00																				2.6				

Estimated Nitrogen Release from Organic Matter

Estimated Total Nitrogen Available to Crop

Last Year's Crop

Fertilizer

Comments

Mr. Curtis J. Koger

Report Date: 7/18/2008

Associated Earth Sciences, Incorporated

Material Received: 6/23/2008

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 245810 SAMPLE : EH080149MW2@175 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes	38560 +/- 450 BP	-24.5 o/oo	38570 +/- 450 BP
Beta - 245811 SAMPLE : EH080149MW2@190 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes	39750 +/- 500 BP	-24.3 o/oo	39760 +/- 500 BP

APPENDIX 4

Ground Water Analytical Data

EDGE ANALYTICAL LABORATORIES

Burlington WA (Corporate Office) | 1620 S Walnut St - 98233 | 800.755.9295 • 360.757.1400 • 360.757.1402fax
Bellingham WA (Microbiology) | 805 Orchard Dr Suite 4 - 98225 | 360.671.0688 • 360.671.1577fax

INORGANIC COMPOUNDS (IOC) REPORT

Client Name: Associated Earth Sciences
P O Box 280
Mount Vernon, WA 98273

Reference Number: 08-08823

Project: EH080149A
Field ID: DW-1
Sample Description: Skagit County
Sampled By: ADL
Sample Date: 6/30/2008
Source Type:

Lab Number: 04618799
Report Date: 7/15/2008
Date Received: 6/30/2008
Sampler Phone:
Peer Review: PM

CAS	ANALYTES	RESULTS	UNITS	PQL	MDL	MCL	Analyst	METHOD	COMMENT
	EPA Regulated								
7440-38-2	ARSENIC	0.004	mg/L	0.001	3.98E-05	0.010	mvp	200.8	
7440-39-3	BARIUM	0.014	mg/L	0.001	0.00016	2	mvp	200.8	
7440-43-9	CADMIUM	ND	mg/L	0.001	4.57E-05	0.005	mvp	200.8	
7440-47-3	CHROMIUM	0.009	mg/L	0.010	0.00018	0.1	mvp	200.8	
7439-97-6	MERCURY	ND	mg/L	0.0002	1.19E-05	0.002	ccn	245.1	
7782-49-2	SELENIUM	ND	mg/L	0.005	7.06E-05	0.05	mvp	200.8	
7440-41-7	BERYLLIUM	ND	mg/L	0.001	1.09E-05	0.004	mvp	200.8	
7440-02-0	NICKEL	ND	mg/L	0.005	0.00028	0.1	mvp	200.8	
7440-36-0	ANTIMONY	ND	mg/L	0.001	1.36E-05	0.006	mvp	200.8	
7440-28-0	THALLIUM	ND	mg/L	0.001	1.33E-05	0.002	mvp	200.8	
57-12-5	CYANIDE, FREE	ND	mg/L	0.040	0.005	0.2	mak	SM4500-CN F	
16984-48-8	FLUORIDE	0.13	mg/L	0.10	0.012	4	bi	300.0	
14797-65-0	NITRITE-N	ND	mg/L	0.10	0.010	1	bi	300.0	
14797-55-8	NITRATE-N	0.78	mg/L	0.10	0.015	10	bi	300.0	
E-10128	TOTAL NITRATE/NITRITE	0.78	mg/L	0.10	0.017	10	bi	300.0	
	EPA Regulated (Secondary)								
7439-89-6	IRON	0.16	mg/L	0.050	0.004	0.3	bi	200.7	
7439-96-5	MANGANESE	ND	mg/L	0.001	2.82E-05	0.05	mvp	200.8	
7440-22-4	SILVER	ND	mg/L	0.010	3.41E-06	0.05	mvp	200.8	
7440-66-6	ZINC	0.120	mg/L	0.005	8.43E-05	5	mvp	200.8	
16887-00-6	CHLORIDE	2.9	mg/L	0.1	0.012	250	bi	300.0	
14808-79-8	SULFATE	15.5	mg/L	0.2	0.04	250	bi	300.0	
	State Regulated								
E-10617	TURBIDITY	1.52	NTU	0.05	0.02	1.0	ccn	180.1	
7440-23-5	SODIUM	14.0	mg/L	1.0	0.03		bi	200.7	
E-11778	HARDNESS	128.2	mg CaCO3/L	3.30	0.055		bi	200.7	
E-10184	ELECTRICAL CONDUCTIVITY	332	uS/cm	10		700	ccn	SM2510 B	
E-11712	COLOR	ND	Color Units	5		15	ccn	SM2120 B	
	State Unregulated								
7439-92-1	LEAD	0.001	mg/L	0.001	9.71E-06	0.015	mvp	200.8	
7440-50-8	COPPER	ND	mg/L	0.005	0.00024	1.3	mvp	200.8	

NOTES:

PQL Practical Quantitation Limit indicates the lower level of quantitation at which an analyte can be determined with a confidence of plus or minus 20%.

MCL (Maximum Contaminant Level) maximum permissible level of a contaminant in water established by EPA; Federal Action Levels are 0.015 mg/L for Lead and 1.3 mg/L for Copper. Sodium has a recommended limit of 20 mg/L. A blank MCL value indicates a level is not currently established.

MDL Method Detection Limit is a theoretical detection limit at which there is a 99% certainty that the analyte concentration is greater than zero.

ND = Not detected above the listed practical quantitation limit (PQL) or not above the Method Detection Limit (MDL), if requested.

FORM: IOC_GEN

CHAIN OF CUSTODY / ANALYSIS REQUEST (PLEASE COMPLETE ALL APPLICABLE SHADED SECTIONS)

PAGE ____ OF ____

REPORT TO: Associated Earth Sciences	BILL TO: Same
ADDRESS: P.O. Box 280	ADDRESS:
CITY: Mount Vernon STATE: WA ZIP: 98273	CITY: STATE: ZIP:
ATTN: Chuck Lindsay	PHONE: FAX:
PHONE: 425-766-2217 FAX:	P.O.#: ATTN:
EMAIL: clindsay@aesgeo.com	☐ VISA ☐ M/C ☐ A/E EXPIRES /
PROJECT NAME: EH08014914	CARD#

FOR LAB USE ONLY

REF#

CHECK REGULATORY PROGRAM

- ☐ SAFE DRINKING WATER ACT
- ☐ CLEAN WATER ACT
- ☐ RCRA / CERCLA
- ☐ OTHER

EDGE ANALYTICAL LABORATORIES

Corporate
1620 S Walnut St
Burlington, WA 98233
1.800.755.9295

Microbiology
805 W. Orchard Dr. Suite 4
Bellingham, WA 98225

INSTRUCTIONS

1. USE ONE LINE PER SAMPLE LOCATION.
2. BE SPECIFIC IN TEST REQUESTS.
3. CHECK OFF ANALYSIS TO BE PERFORMED FOR EACH SAMPLE LOCATION.
4. ENTER NUMBER OF CONTAINERS.

TURN AROUND TIME REQUIRED

- ☒ STANDARD
- ☐ HALF-TIME (50% SURCHARGE)
- ☐ QUICKEST (100% SURCHARGE) PHONE CALL REQ.
- ☐ EMERGENCY (PHONE CALL REQUIRED)

ANALYSIS REQUESTED

	SAMPLE ID	LOCATION	GRAB/ COMP.	MATRIX	DATE	TIME	Primary ALD Fumigants	Secondary ALD Fumigants	DOC TOT				NUMBER OF CONTAINERS	SPECIAL INSTRUCTIONS/ CONDITIONS ON RECEIPT
1	DW-1	Skagit Co.	X		6/30/08	11:50	☒	☒	☒	☐	☐	☐	3	
2							☐	☐	☐	☐	☐	☐		
3							☐	☐	☐	☐	☐	☐		
4							☐	☐	☐	☐	☐	☐		
5							☐	☐	☐	☐	☐	☐		
6							☐	☐	☐	☐	☐	☐		
7							☐	☐	☐	☐	☐	☐		
8							☐	☐	☐	☐	☐	☐		
9							☐	☐	☐	☐	☐	☐		
10							☐	☐	☐	☐	☐	☐		

08-08823
18799

SAMPLED BY: ALD PHONE: 425-766-1693 FAX: EMAIL: adaniels@aesgeacan 3 ◀TOTAL CONTAINERS

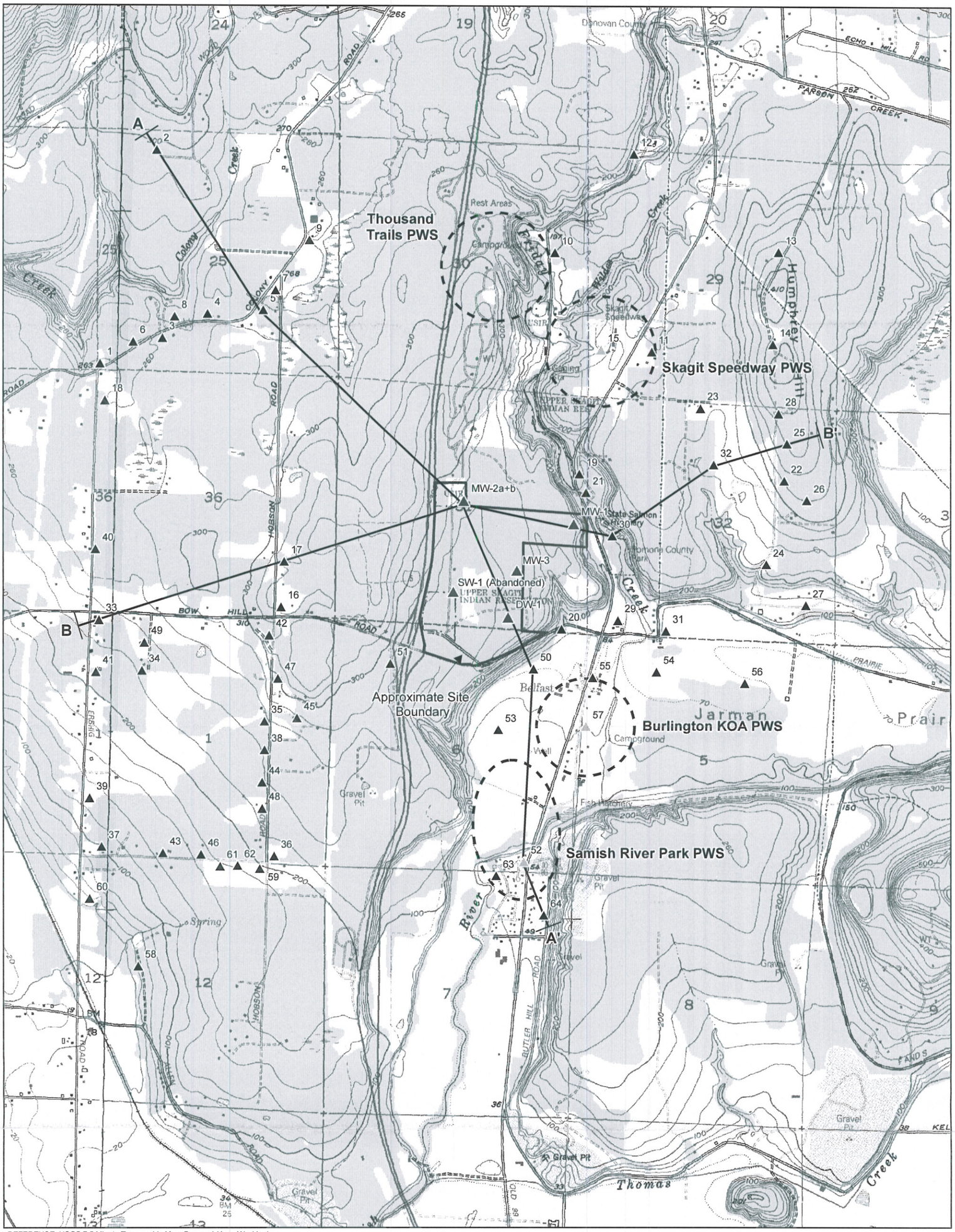
SAMPLE RECEIPT REQUESTED (MUST INCLUDE FAX OR EMAIL) ☐

RELINQUISHED BY	DATE	TIME	RECEIVED BY	DATE	TIME
[signature]	6/30/08	17:16	L. Kenaugh	6/30/08	17:16

	YES	NO	N/A
CUSTODY SEALS INTACT	☐	☐	☐
SAMPLE TEMP 20°C SATISFACTORY	☐	☐	☐
SAMPLES RECEIVED INTACT	☐	☐	
CHAIN OF CUSTODY & LABELS AGREE	☐	☐	

FORM: COC 10-02-2007

Okay to [illegible]



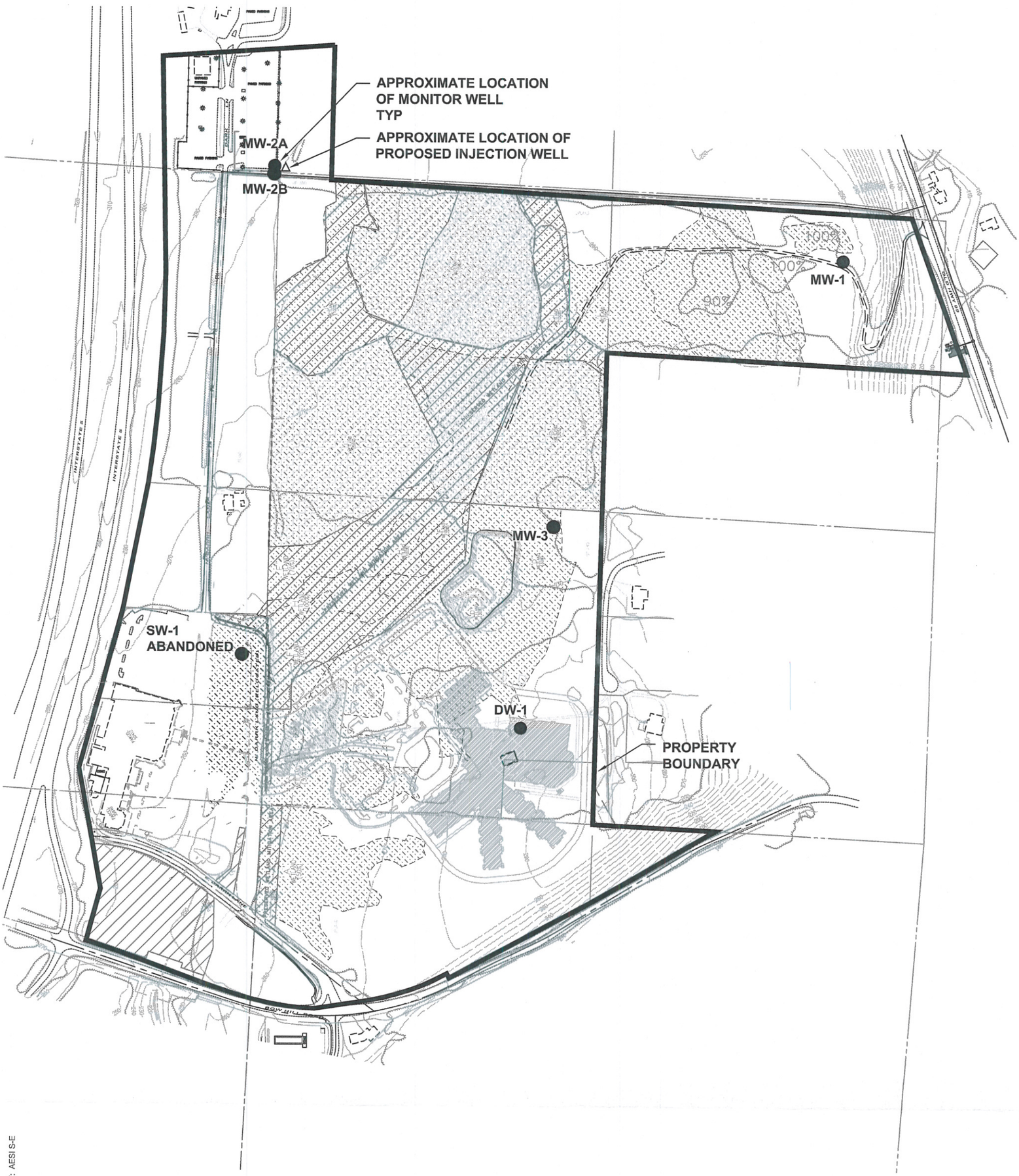
REFERENCE: USGS 7.5 Minute Topographic Map Bow and Alger, Washington.

N:\EH080149A Upper Skagit Tribe\Site Vicinity and Well Location Map.mxd

Associated Earth Sciences, Inc.

SITE VICINITY AND WELL LOCATION MAP
UPPER SKAGIT TRIBE
SKAGIT COUNTY, WASHINGTON

FIGURE 1
DATE 9/08
PROJ. NO. EH080149A



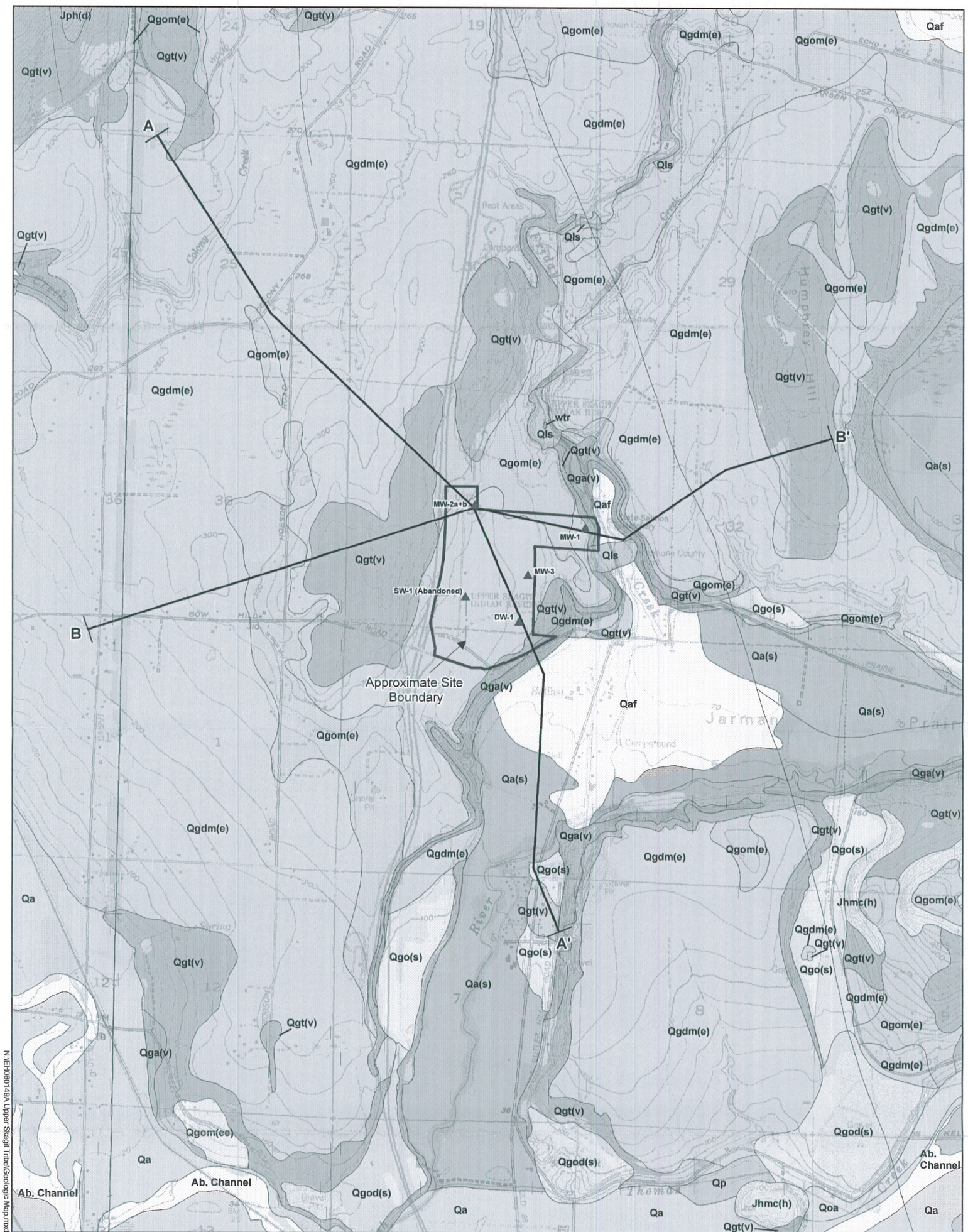
Reference: Wilson Survey/Engineering

Associated Earth Sciences, Inc.

SITE AND EXPLORATION PLAN
UPPER SKAGIT TRIBE
SKAGIT COUNTY, WASHINGTON

FIGURE 2
DATE 10/08
PROJECT NO. EH080149A

080149 USIT Monitor Wells \ 080149 Site and Expl REV 10-08.dwg LAYOUT: AESI S-E



REFERENCE: Geology - Adapted from: Geologic Map and Interpreted History of the Bow and Alger 7.5-minute Quadrangles, Western Skagit County, Washington OFR 98-5 WA Division of Geology and Earth Resources - 1998.
USGS 7.5 Minute Topographic Map Bow and Alger, Washington.

Legend

- ▲ AESI Ground Water Monitoring Well
- Geologic Profiles
- Approximate Site Location

N

0 1,000 2,000 Feet

N:\EH080149A Upper Skagit Tribe\Geologic Map.mxd

Associated Earth Sciences, Inc.

GEOLOGIC MAP
UPPER SKAGIT TRIBE
SKAGIT COUNTY, WASHINGTON

FIGURE 3
DATE 8/08
PROJ. NO. EH080149A

GEOLOGIC MAP UNIT DESCRIPTIONS

QUATERNARY SEDIMENTARY DEPOSITS

Qa	ALLUVIUM OF THE SKAGIT RIVER VALLEY (HOLOCENE) - CLAY, SILT, AND FINE SAND WITH MINOR SAND AND COBBLY GRAVEL
Qa(s)	ALLUVIUM OF THE SAMISH RIVER VALLEY (HOLOCENE) - COBBLY GRAVEL, GRAVEL, SAND, SILT, CLAY, RARE PEAT.
Qoa	OLDER ALLUVIUM AND LAHAR RUN-OUT DEPOSITS OF THE SKAGIT RIVER VALLEY (HOLOCENE) - IRON-STAINED SAND, SILT, AND CLAY
Qaf	ALLUVIAL FAN DEPOSITS (HOLOCENE AND PLEISTOCENE?) - COBBLE, SAND, AND BOULDER DIAMICTON; LOCAL LENSES OF GRAVEL, SILT, AND CLAY
Qls	LANDSLIDE DEPOSITS (HOLOCENE AND PLEISTOCENE?) - DIAMICTON, CONSISTING OF ANGULAR TO ROUNDED BOULDERS, COBBLES AND GRAVEL IN A SAND, SILT, AND/OR CLAY MATRIX

SUMAS STADE

Qgo(s)	FLUVIAL OUTWASH (PLEISTOCENE) - SAND, COBBLY GRAVEL; LOCALLY WITH BOULDERS, SANDY GRAVEL AND RARE SILTY SAND
Qgod(s)	DELTAIC GLACIAL OUTWASH - GRAVEL AND SAND WITH RARE SILT INTERBEDS; MASSSIVE TO THICKLY BEDDED

EVERSON INTERSTADE

Qgdm(e)	GLACIOMARINE DRIFT - CLAYEY SILT, SILTY CLAY, CLAY, AND CLAY-RICH DIAMICTON
Qgom(e)	FLUVIAL-DELTAIC-TURBIDITIC GLACIOMARINE OUTWASH - SAND, GRAVEL, WITH MINOR INTERLAYERED SILTS AND SILTY SANDS; RARE DIAMICTON
Qgom(ee)	EMERGENCE BEACH DEPOSITS - SAND AND GRAVEL ON WAVE-CUT TOPOGRAPHIC BENCHES

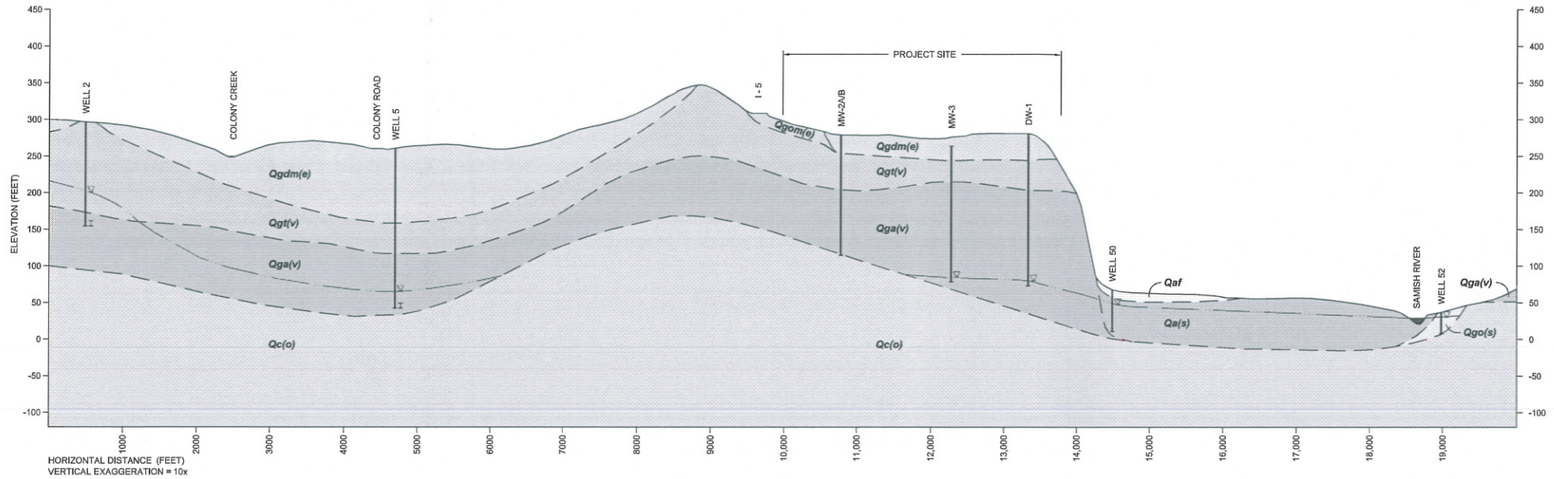
VASHON STADE

Qga(v)	ADVANCE OUTWASH - SANDY GRAVEL, SAND AND SCATTERED LENSES OF COBBLY GRAVEL WITH LESSER SILT AND CLAY INTERBEDS; MOSTLY COMPOSED OF MODERATELY TO WELL-SORTED, DISTINCTLY STRATIFIED MEDIUM TO COARSE SAND AND PEBBLY SAND WITH MINOR AMOUNTS OF FINE SAND, SILTY SAND, OR SANDY SILT AND SCATTERED LENSES AND LAYERS OF PEBBLE-COBBLE GRAVEL
Qgt(v)	TILL - UNSTRATIFIED, DENSE TO VERY DENSE DIAMICTON CONSISTING OF CLAY, SILT, SAND AND GRAVEL

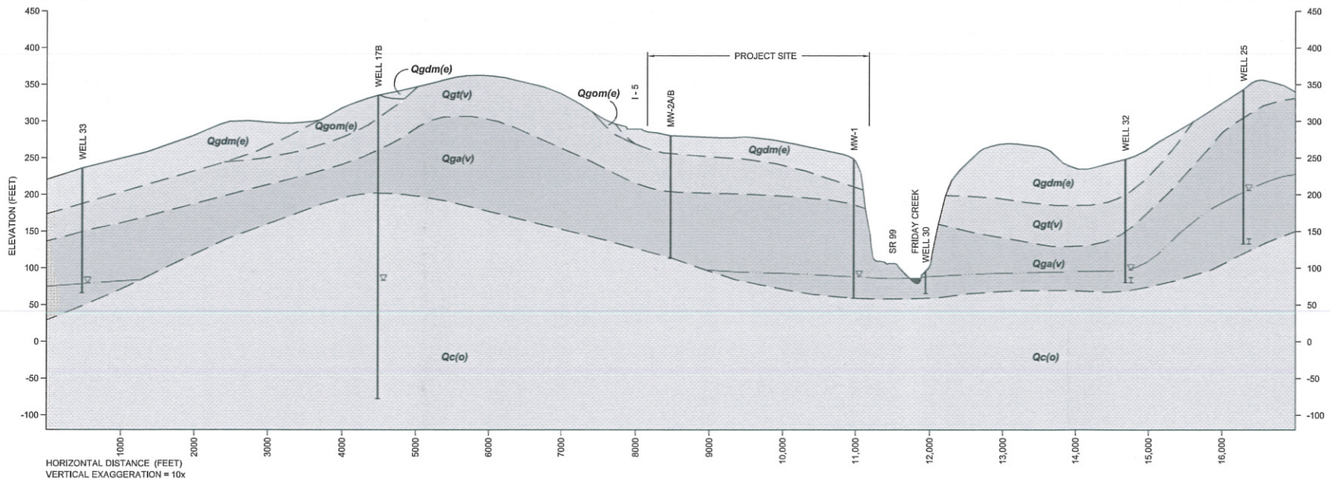
OLYMPIA NON-GLACIAL INTERVAL

Qc(o)	OLYMPIA NON-GLACIAL DEPOSITS (PLEISTOCENE) - COMPOSITIONALLY HETEROGENEOUS SEDIMENTS COMPOSED OF DENSE TO VERY DENSE SILT, SILTY SAND, GRAVELLY SAND AND SILTY CLAY WITH ORGANIC MATERIAL

A NORTHWEST — SOUTHEAST A'



B WEST — EAST B'



LEGEND:

QUATERNARY SEDIMENTARY DEPOSITS
- Qa — ALLUVIUM OF THE SKAGIT RIVER VALLEY (HOLOCENE)
- Qa(s) — ALLUVIUM OF THE SAMISH RIVER VALLEY (HOLOCENE)
- Qoa — OLDER ALLUVIUM AND LAHAR RUN-OUT DEPOSITS OF THE SKAGIT RIVER VALLEY (HOLOCENE)
- Qaf — ALLUVIAL FAN DEPOSITS (HOLOCENE AND PLEISTOCENE?)
- Qls — LANDSLIDE DEPOSITS (HOLOCENE AND PLEISTOCENE?)

SUMAS STADE
- Qgo(s) — FLUVIAL OUTWASH (PLEISTOCENE)
- Qgod(s) — DELTAIC GLACIAL OUTWASH

EVERSON INTERSTADE
- Qgdm(e) — GLACIOMARINE DRIFT
- Qgom(e) — FLUVIAL-DELTAIC-TURBIDITIC GLACIOMARINE OUTWASH
- Qgom(ee) — EMERGENCE BEACH DEPOSITS

VASHON STADE
- Qgt(v) — GLACIAL LODGEMENT TILL
- Qga(v) — ADVANCE OUTWASH

OLYMPIA NON-GLACIAL INTERVAL
- Qc(o) — OLYMPIA NON-GLACIAL DEPOSITS (PLEISTOCENE)

▽ STATIC WATER LEVEL MEASURED
I WELL SCREEN

Associated Earth Sciences, Inc.

Everett Office
2911 1/2 Hewitt, Suite 2
Everett, WA 98201
(425) 259-0522

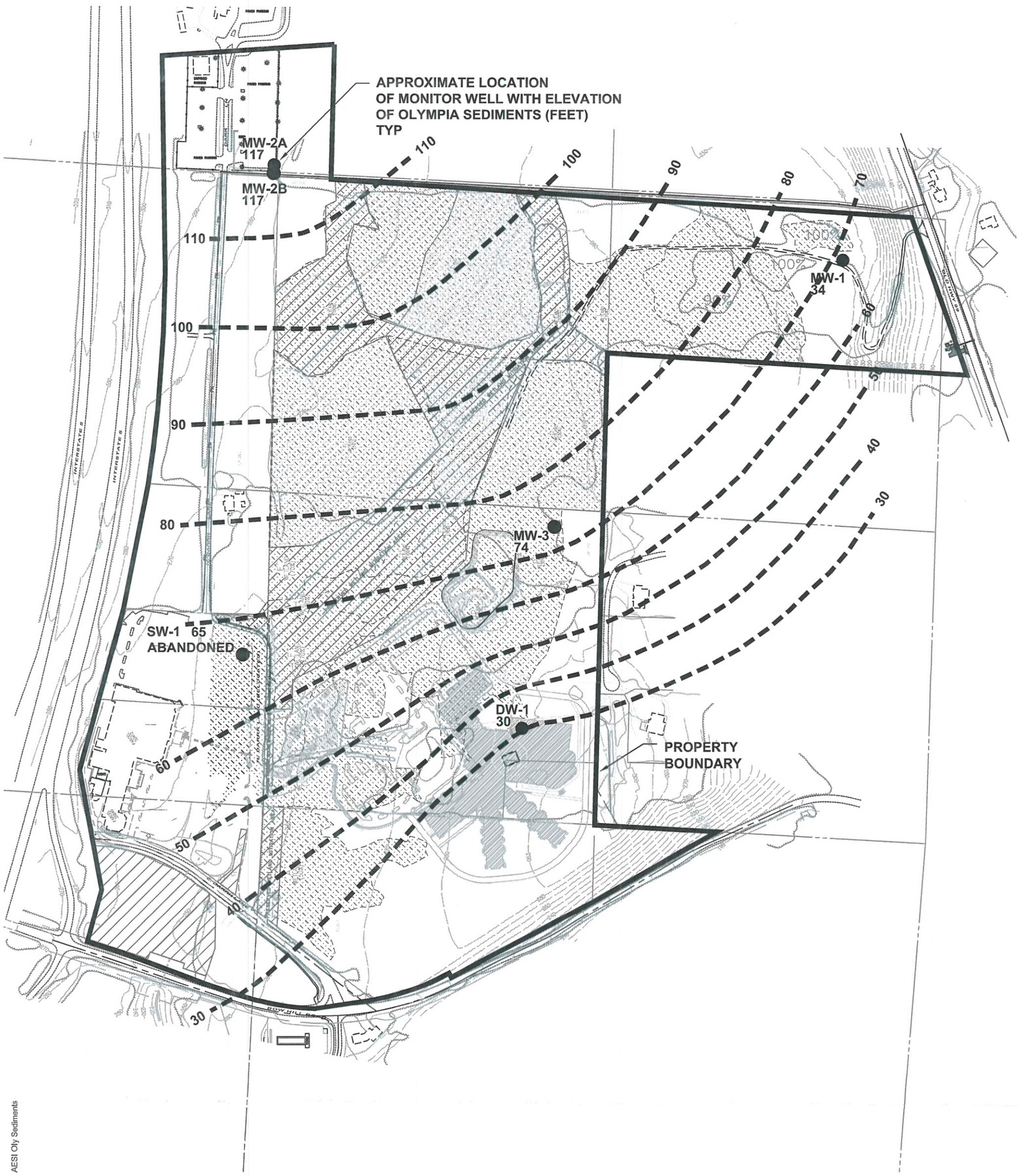
www.aesgeo.com

Kirkland Office
911 Fifth Avenue
Kirkland, WA 98033
(425) 827-7701

GENERALIZED GEOLOGIC CROSS-SECTIONS
UPPER SKAGIT TRIBE
SKAGIT COUNTY, WASHINGTON

DRAWN BY:	EIN
CHECKED BY:	CSL
DATE	10/08
PROJECT NO.	EH080149A
FIGURE	5

080149 USIT Monitor Wells \ 080149 Geo Sects.dwg LAYOUT: Sects A-B



N

0 200 400
FEET

Reference: Wilson Survey/Engineering

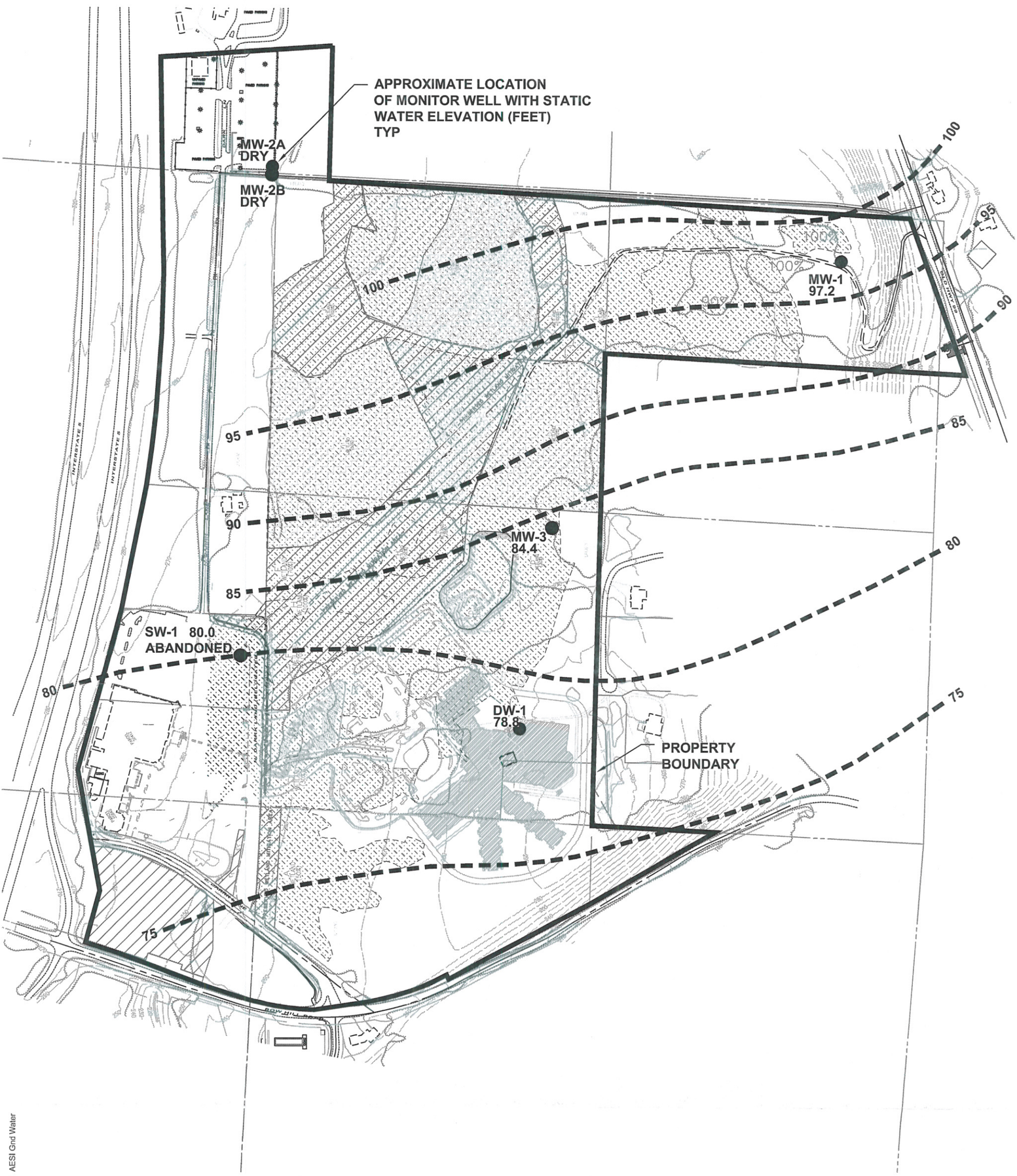
Associated Earth Sciences, Inc.

ELEVATION TOP OF OLYMPIA SEDIMENTS

UPPER SKAGIT TRIBE
SKAGIT COUNTY, WASHINGTON

FIGURE 7
DATE 10/08
PROJECT NO. EH080149A

080149 USIT Monitor Wells \ 080149 Site and Explr REV 10-08.dwg LAYOUT: AESI Oly Sediments



Reference: Wilson Survey/Engineering

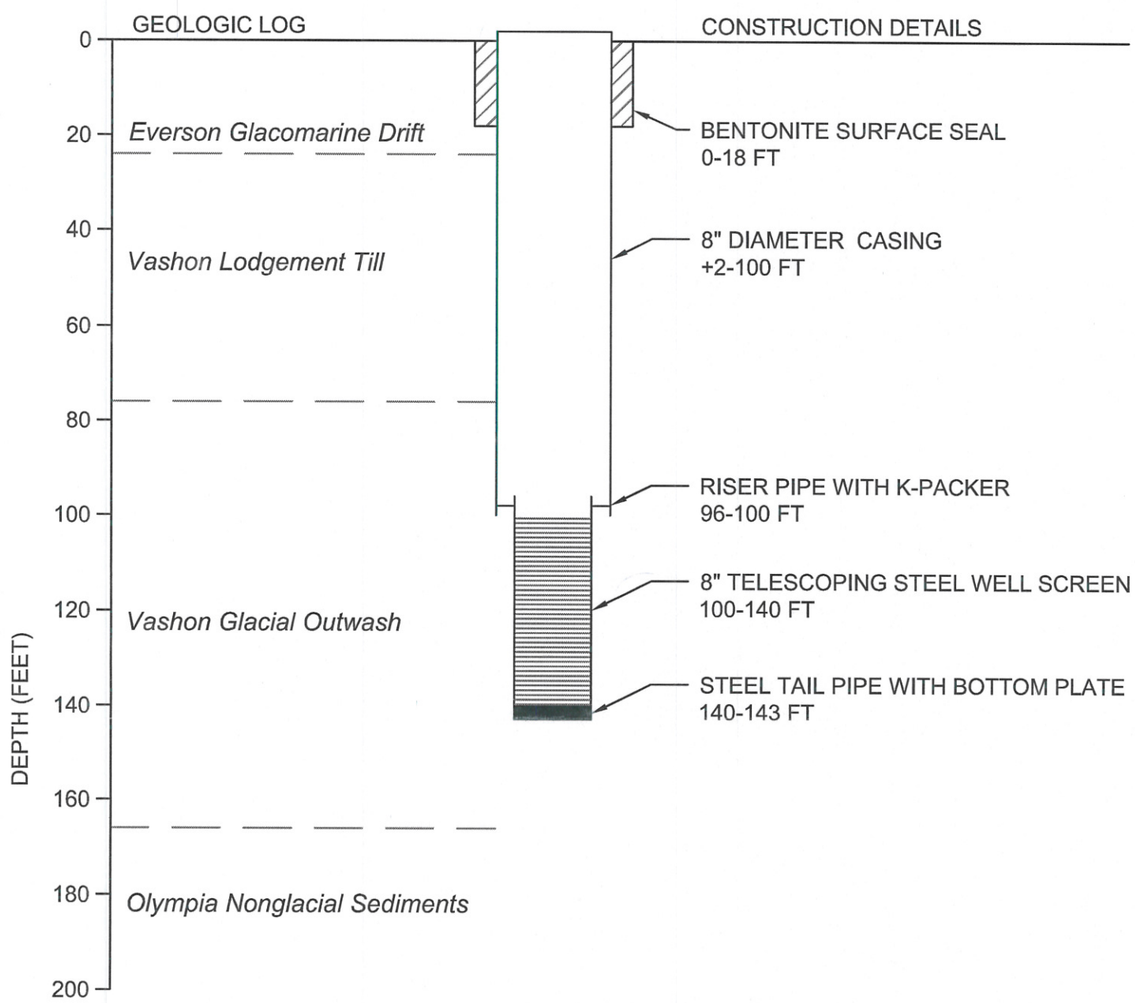
080149 USIT Monitor Wells \ 080149 Site and Explr REV 10-08.dwg LAYOUT: AESI Gnd Water

Associated Earth Sciences, Inc.

GROUND WATER CONTOUR MAP

UPPER SKAGIT TRIBE
SKAGIT COUNTY, WASHINGTON

FIGURE 8
DATE 10/08
PROJECT NO. EH080149A



080149 USIT Monitor Wells \ 080149 Injection Well.dwg LAYOUT: Figure 8

Associated Earth Sciences, Inc.

PILOT INJECTION WELL SCHEMATIC

UPPER SKAGIT INDIAN TRIBE
SKAGIT COUNTY, WASHINGTON

FIGURE 9
DATE 10/08
PROJECT NO. EH080149A